Aggregate Biophysical Indicators of Environmental State

Provides guidance on deriving aggregate biophysical indicators of environmental state from ocean accounts.

Version 0.9.5 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 4
3.1 Indicator Framework 5
3.2 Compilation Procedure for Aggregate Indicators 8
3.3 Extent-Based Indicators 11
3.4 Condition-Based Indicators 12
3.5 Worked Example: Coastal Ecosystem Condition Indicators 18
3.6 Aggregation Approaches 22
3.7 Marine-Specific Applications 24
4. Acknowledgements 27
5. References 27

ABOUT THIS GUIDANCE

RECOMMENDED CITATION
Aggregate Biophysical Indicators of Environmental State (2026) (GOAP Technical Guidance on Ocean Accounting, TG-2.1, v0.9.9). GOAP Secretariat. https://guidance.oceanaccounts.org/resources/TG-2.1.pdf

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

OUTCOME

This Circular provides guidance on deriving aggregate biophysical indicators of environmental state from ocean accounts. Aggregate indicators synthesise complex, multi-dimensional information about marine and coastal ecosystem condition into accessible summary measures that support policy communication, tracking of conservation targets, and comparison across spatial units and time periods. Building on the ecosystem condition accounting framework established in TG-3.1 Asset Accounts, this Circular explains the conceptual and methodological foundations for constructing extent-based indicators, condition-based indicators, and composite indices for marine ecosystems. Readers will understand the indicator hierarchy from raw condition variables through normalised indicators to aggregate condition indices, the role of reference conditions in indicator derivation, and the specific applications and limitations of aggregate indicators for ocean accounting.

Sections 3.4 and 3.6 are normative for the publication. Every condition indicator in the Technical Guidance, including those in Section 1 decision circulars and Section 6 thematic circulars, is derived using the transformation in Section 3.4.1 – with its inverse-polarity variant and, for pH and other logarithmic-scale variables, the categorical step deduction set out there – and aggregated using the methods and defaults in Section 3.6. Section 3.6.2 additionally specifies how a condition trajectory is projected under a management scenario, which planning and appraisal circulars rely on for scenario comparison. The guidance enables compilers to produce policy-relevant summary statistics from detailed ocean accounts whilst maintaining the transparency and traceability essential for scientific credibility.

Aggregate biophysical indicators support a range of decision use cases for governments managing ocean resources:

MPA effectiveness monitoring: Indicators derived from extent and condition accounts enable tracking of whether marine protected areas are achieving their conservation objectives – see TG-1.3 OA and Marine Spatial Management.

SDG 14 reporting: Extent indicators align directly with SDG indicator 14.5.1 (marine protected area coverage), whilst condition indicators support assessment of SDG target 14.2 on sustainable management and protection of marine and coastal ecosystems.

Ocean health report cards: Composite condition indices aggregated across multiple ecosystem types produce summary scores suitable for public communication through ocean health scorecards and state-of-environment reports.

Fisheries management thresholds: Condition indicators for fish nursery habitats (coral reefs, seagrass meadows, mangroves) inform spatial management decisions in fisheries – see TG-1.5 OA and Fisheries Management.

DRAFT

1. Outcome

¶1 This Circular provides guidance on deriving aggregate biophysical indicators of environmental state from ocean accounts. Aggregate indicators synthesise complex, multi-dimensional information about marine and coastal ecosystem condition into accessible summary measures that support policy communication, tracking of conservation targets, and comparison across spatial units and time periods. Building on the ecosystem condition accounting framework established in **TG-3.1 Asset Accounts**, this Circular explains the conceptual and methodological foundations for constructing extent-based indicators, condition-based indicators, and composite indices for marine ecosystems. Readers will understand the indicator hierarchy from raw condition variables through normalised indicators to aggregate condition indices, the role of reference conditions in indicator derivation, and the specific applications and limitations of aggregate indicators for ocean accounting.

¶2 **Sections 3.4 and 3.6 are normative for the publication.** Every condition indicator in the Technical Guidance, including those in Section 1 decision circulars and Section 6 thematic circulars, is derived using the transformation in Section 3.4.1 — with its inverse-polarity variant and, for pH and other logarithmic-scale variables, the categorical step deduction set out there — and aggregated using the methods and defaults in Section 3.6. Section 3.6.2 additionally specifies how a condition trajectory is projected under a management scenario, which planning and appraisal circulars rely on for scenario comparison. The guidance enables compilers to produce policy-relevant summary statistics from detailed ocean accounts whilst maintaining the transparency and traceability essential for scientific credibility.

¶3 Aggregate biophysical indicators support a range of decision use cases for governments managing ocean resources:

¶4 **MPA effectiveness monitoring**: Indicators derived from extent and condition accounts enable tracking of whether marine protected areas are achieving their conservation objectives — see **TG-1.3 OA and Marine Spatial Management**.

¶5 **SDG 14 reporting**: Extent indicators align directly with SDG indicator 14.5.1 (marine protected area coverage), whilst condition indicators support assessment of SDG target 14.2 on sustainable management and protection of marine and coastal ecosystems.

¶6 **Ocean health report cards**: Composite condition indices aggregated across multiple ecosystem types produce summary scores suitable for public communication through ocean health scorecards and state-of-environment reports.

¶7 **Fisheries management thresholds**: Condition indicators for fish nursery habitats (coral reefs, seagrass meadows, mangroves) inform spatial management decisions in fisheries — see **TG-1.5 OA and Fisheries Management**.

2. Requirements

¶1 This Circular requires familiarity with:

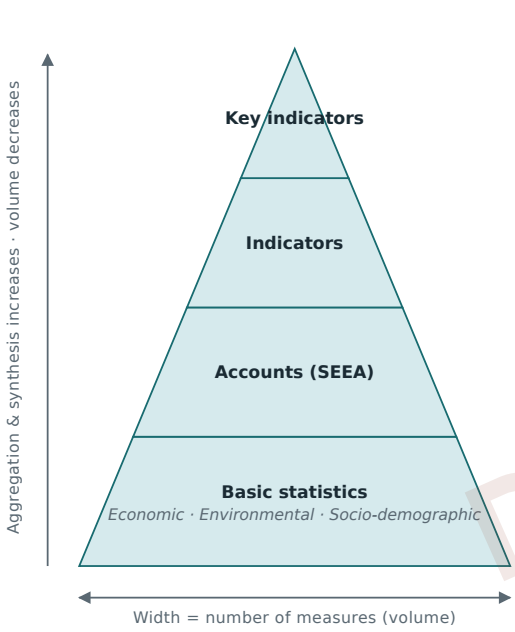
- ¶2 **TG-0.1 General Introduction to Ocean Accounts** — for the conceptual framework and key components of Ocean Accounts
- ¶3 **TG-0.2 Overview of Relevant Statistical Standards** — for the methodological foundations provided by SNA 2025, SEEA CF, and SEEA EA
- ¶4 **TG-3.1 Asset Accounts** — for the structure of ecosystem extent and condition accounts from which indicators are derived. The underlying methodology follows SEEA Ecosystem Accounting (2021), Chapter 5

DRAFT

- ¶5 **TG-0.7 Quality Assurance** – for quality management principles that apply to indicator construction, including uncertainty documentation and fitness-for-purpose assessment

3. Guidance Material

¶1 Within the ocean accounting system, information products are organised in a hierarchical structure sometimes described as an information pyramid [1]. At the base of this pyramid sit data and statistics: the raw observations from monitoring networks, surveys, and remote sensing platforms. Accounts occupy an intermediate level, organising data according to internationally agreed classifications and accounting rules. From these accounts, indicators are derived as summary measures that distil complex accounting information into policy-relevant signals. Key indicators at the apex aggregate further to support strategic analysis.



Role	Audience	Properties
Raise awareness; communication & implementation	General public, journalists, high-level policy-makers	Aggregated / composite indicators
Support decision-making & policy coherence	Officials, policy analysts, managers, stakeholders	Large sets of indicators
Support analysis & in-depth studies	Policy analysts, researchers, statisticians	Detailed, consistent structure; multi-purpose
Provide primary measurement & source data	Researchers, statisticians, data providers	Detailed single-source statistics; high volume

DRAFT

Figure 2.1.1 The information pyramid condenses basic statistics through SEEA accounts into fewer, higher-value indicators for progressively higher-level audiences. Height encodes aggregation; width encodes volume of statistics versus composite key indicators.

Source: SEEA EA 2024, Figure 14.1.

Adapted from: SEEA EA 2024, Figure 14.1 (information pyramid); redrawn in the GOAP figure palette with role / audience / properties tiers.

¶2 Indicators compiled from accounts are more comparable across space and time than indicators taken directly from raw data, as the accounting process applies standardised classifications, reference conditions, and valuation rules that harmonise otherwise disparate data streams. TG-2.1 addresses the derivation of aggregate biophysical indicators (the upper layers of the information pyramid), whilst the construction of the accounts is addressed in the TG-3.x series (particularly **TG-3.1 Asset Accounts**), and data production methods in the TG-4.x series.

¶3 Ecosystem condition accounts compile detailed information on the biophysical characteristics of ecosystems that serve as the 'data foundation' for aggregate indicators [2]. See **TG-3.2 Flows from Environment to Economy** for full account structure and compilation procedure [3]. SEEA

Ecosystem Accounting establishes a three-stage hierarchical approach to ecosystem condition measurement [4]. The first stage records ecosystem condition variables: the raw observations of ecosystem characteristics in their original measurement units. The second stage derives ecosystem condition indicators by normalising variables against reference levels, creating comparable measures on a common scale. The third stage involves optional aggregation into ecosystem condition indices, which combine multiple indicators into summary measures for communication purposes. This Circular focuses primarily on the second and third stages, and provides guidance on deriving indicators and indices for marine and coastal ecosystems within the ocean accounting framework. This Circular supports the indicator derivation and presentation guidance in **TG-1.3 OA and Marine Spatial Management** and **TG-1.5 OA and Fisheries Management**.

3.1 Indicator Framework

¶1 The indicator framework for ocean accounting connects raw biophysical data to policy-relevant summary statistics through a systematic process of classification, normalisation, and aggregation.

3.1.1 Types of biophysical indicators

¶1 Biophysical indicators in ocean accounting fall into three broad categories based on what they measure:

¶2 **Extent indicators** measure the spatial coverage of marine ecosystem types, expressed in units of area (hectares, square kilometres) or, for certain ecosystems, length (kilometres of coastline) or volume (cubic kilometres of water column) [5]. Extent indicators include total area of ecosystem types, changes in extent over time, and proportional coverage within accounting areas. Key examples for marine ecosystems include coral reef area, seagrass meadow extent, mangrove forest coverage, and kelp forest distribution.

¶3 **Condition indicators** measure the health and integrity of ecosystems relative to a reference state, typically expressed as dimensionless indices on a standardised scale (commonly 0-1 or 0-100) [6]. Condition indicators are derived from raw condition variables through normalisation against reference levels. The SEEA Ecosystem Condition Typology (ECT) organises condition characteristics into six classes [7]. Table 1 below summarises these classes with marine-specific examples and typical data sources:

DRAFT

ECT Class	Description	Marine Examples	Data Sources
A1 Physical state	Abiotic physical characteristics	Sea temperature, pH, depth	Remote sensing, buoys
A2 Chemical state	Abiotic chemical characteristics	Dissolved O2, nutrients, salinity	Water sampling
B1 Compositional state	Biotic diversity and composition	Species richness, community structure	Surveys, eDNA
B2 Structural state	Biotic physical architecture	Coral cover, canopy height, biomass	Remote sensing, transects
B3 Functional state	Ecosystem processes	Primary productivity, recruitment	Modelling, sampling
C Landscape context	Spatial configuration	Fragmentation, connectivity	GIS analysis

¶4 **Combined extent-condition indicators** integrate information on both the area and quality of ecosystems to give measures of effective ecosystem capacity. These include weighted indices where condition scores modify extent values, and functional capacity measures that combine area with condition-dependent service delivery potential [8]. For example, an “effective coral reef area” indicator might weight reef extent by a condition index. The resulting single measure captures both spatial coverage and ecological quality.

¶5 Combined extent-condition indicators represent an active area of methodological development for ocean accounting. Whilst SEEA EA does not prescribe a single approach, the combination of extent and condition information addresses a policy need: distinguishing between situations where a large area of ecosystem exists in degraded condition versus a smaller area in good condition. Compilers should present combined indicators alongside their disaggregated components, so that users can identify whether changes in the combined measure are driven by extent loss, condition decline, or both.

3.1.2 Relationship to accounts

¶1 Biophysical indicators derive from and remain linked to the underlying accounting tables. That link ensures that aggregate indicators can be traced back to their component data, which supports verification and allows users to investigate the drivers of observed changes.

¶2 Figure 2.1.2 shows the general ecosystem accounting framework (adapted from 2025 SNA Figure 35.2)[9].

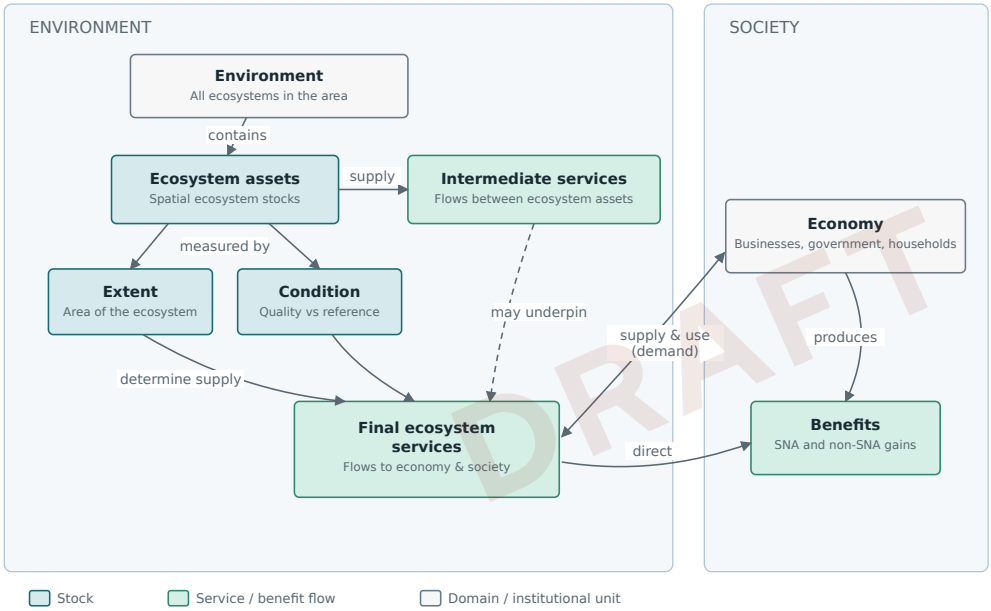


Figure 2.1.2 Ecosystem assets measured by extent and condition supply final ecosystem services to the economy and society. Intermediate services stay within the Environment. Nodes coloured by stock, flow, or institutional domain; economy nested within society.

¶3 The ecosystem condition variable account records raw observations of condition characteristics for each ecosystem type within the accounting area[10]. For example, a condition variable account for coral reef ecosystems might record coral cover percentage, fish biomass density, water temperature, and species richness. These values are recorded in their native measurement units (percentages, kg/hectare, degrees Celsius, species counts).

¶4 The ecosystem condition indicator account derives normalised indicators from variables by applying reference levels[11]. The normalisation process transforms diverse measurement units into a common scale that enables comparison across characteristics and aggregation. A coral cover of 35% might become a condition indicator of 0.70 if the reference condition is 50% cover.

¶5 The ecosystem condition index aggregates individual indicators into composite measures for each ecosystem type, and potentially across ecosystem types for the entire accounting area[12]. Compilers should document the aggregation method (arithmetic mean, geometric mean, weighted average, or another approach) together with its implications for the resulting index.

¶6 The methods for remote sensing and spatial data that underpin extent and condition measurement are addressed in **TG-4.1 Remote Sensing Data**, whilst **TG-4.2 Survey Methods** covers field survey approaches for condition variable collection.

3.1.3 Principles of indicator design

¶1 Effective biophysical indicators for ocean accounting should satisfy several design principles established in international statistical and scientific guidance[13]. Table 3.1.3 below summarises these principles.

Principle	Description
Relevance	Indicators should measure characteristics that are meaningful for ecosystem integrity and responsive to the pressures or management interventions of interest. For marine ecosystems, indicators should capture characteristics relevant to ocean-specific processes such as productivity, biodiversity, water quality, and habitat structure.
Scientific validity	Indicators should be based on sound scientific understanding of ecosystem function and established relationships between measured characteristics and ecosystem health. Where possible, indicators should align with validated assessment frameworks such as Essential Ocean Variables (EOVs) and Essential Biodiversity Variables (EBVs)[14] .
Measurability	Indicators should be based on data that can be collected consistently across space and time using available methods and resources. For many marine ecosystems, this implies prioritising indicators that can be derived from remote sensing, systematic surveys, or monitoring networks with established protocols.
Sensitivity	Indicators should be sensitive to changes in ecosystem state at policy-relevant timescales, neither so volatile as to reflect noise rather than signal, nor so stable as to miss important changes.
Comparability	Indicators should be constructed in ways that enable meaningful comparison across different areas, ecosystem types, and time periods. The use of common reference conditions and standardised normalisation approaches supports comparability.
Transparency	The methods for constructing indicators should be fully documented, enabling independent verification and facilitating understanding of what the indicator does and does not capture.
Uncertainty documentation	Indicators should be accompanied by information on the uncertainty associated with their values, including measurement uncertainty in the underlying data, model uncertainty in the normalisation process, and sensitivity to methodological choices such as reference condition selection and aggregation weights. The quality management principles in **TG-0.7 Quality Assurance** apply directly to indicator construction and should inform the documentation of confidence levels and data quality ratings for published indicators.

3.1.4 The normalised 0-1 condition index pattern

¶1 The normalisation of a raw condition variable against a reference level to produce a dimensionless score on a 0-1 scale is the standard biophysical-indicator pattern used throughout ocean accounting. Compilers should treat this pattern as the default form for any indicator derived from a condition variable, regardless of the ecosystem type, ECT class, or measurement units of the underlying observation.

¶2 The pattern has three conceptual components:

DRAFT

- ¶3 **A condition variable** measured in its native units (concentration, percentage cover, count, temperature, index, etc.).
- ¶4 **A reference level** that defines what the indicator is being compared against. The reference level is anchored at one end of the scale (the value corresponding to "reference condition" or good state) and bounded at the other end (the value corresponding to fully degraded condition). The choice of reference level is a separate methodological decision addressed in Section 3.4.2.
- ¶5 **A normalised indicator** expressed on a fixed 0-1 scale, where 1 represents the reference condition and 0 represents the fully degraded state. Values between 0 and 1 represent intermediate states, interpretable as the proportional distance from degraded to reference condition.

¶6 Adopting this pattern as the standard form for biophysical indicators delivers several benefits. It places indicators derived from different variables, ECT classes, and ecosystem types onto a common scale, so they can be presented side by side, compared across spatial units and time, and aggregated into composite indices without unit conversion. The empirical measurement (the variable) is held separate from the normative or scientific judgement embedded in the reference level, so both elements remain visible and revisable. Traceability from the headline indicator back to the underlying observation is preserved, because the variable value, reference level, and polarity assignment are all recorded explicitly in metadata. For downstream users (policy audiences, MPA managers, SDG reporters), the pattern fixes a consistent interpretive convention: a score closer to 1 always indicates better condition relative to the chosen reference, irrespective of which characteristic is being measured.

¶7 The pattern should be applied consistently across all condition-derived indicators in ocean accounts. Section 3.4.1 sets out the formula and parameters used to implement the pattern, including the treatment of variables with inverse polarity (where higher measured values indicate lower condition). Section 3.4.2 addresses the selection and documentation of reference levels. Section 3.4.3 addresses aggregation of normalised indicators into composite indices, which is only well-defined because all contributing indicators share the 0-1 scale established by this pattern.

¶8 Some indicators are not derived through normalisation against a reference level and should not be forced onto the 0-1 scale. These include extent indicators expressed in absolute area units, and stock status indicators expressed relative to fishery reference points (B/B_MSY, F/F_MSY). The pattern applies specifically to indicators derived from ecosystem condition variables as defined in the SEEA EA Ecosystem Condition Typology.

DRAFT

3.2 Compilation Procedure for Aggregate Indicators

¶1 This section outlines the step-by-step procedure for compiling aggregate biophysical indicators from ocean accounts.

¶2 All computed indicator values should be rounded to two decimal places using standard rounding (0.5 rounds up) and this convention applied consistently across all worked tables and published outputs.

Step 1: Identify indicator set and policy requirements

¶1 The compilation process begins with identifying which indicators are needed to serve the intended policy use cases. This involves reviewing policy commitments (SDG targets, national conservation strategies, MPA management plans) to determine reporting requirements, consulting with decision-makers and stakeholders to understand their information needs, and assessing data availability and quality to ensure feasibility.

¶2 For ocean accounting, priority indicator sets typically include those summarised in Table 3.2.1 below.

Indicator Set	Description
Extent change indicators	For ecosystem types covered by international targets (mangroves, coral reefs, seagrass meadows).
Condition indicators	Spanning all six ECT classes to provide full assessment coverage.
Combined extent-condition indicators	For ecosystems that deliver critical services (coastal protection, fish nursery habitat, carbon sequestration).
Headline composite indices	For high-level communication in state-of-environment reports and ocean health scorecards.

¶3 The selection process should be documented in a technical specification that records the rationale for each indicator, its intended use, and the accounts from which it will be derived.

Step 2: Source data from accounts

¶1 With the indicator set identified, the next step is to extract the required data from the underlying asset accounts compiled following **TG-3.1 Asset Accounts**. For extent indicators, this involves extracting opening and closing extent values from ecosystem extent accounts, calculating net change, and expressing change as both absolute values (hectares) and relative values (percentage change from opening extent).

¶2 For condition indicators, the process involves extracting condition variable values from condition variable accounts for opening and closing periods, retrieving reference condition values for each variable, and checking that measurement units are consistent across accounting periods. The data extraction should preserve links to the spatial units (ecosystem assets or BSUs) from which the data originate. These links enable disaggregated analysis when needed.

¶3 Data quality ratings from **TG-0.7 Quality Assurance** should be carried forward from the accounts to the indicators, documenting the fitness-for-purpose of the underlying data.

Step 3: Apply reference conditions

¶1 Reference conditions establish the benchmark against which current ecosystem state is measured[15]. For each condition variable, the compiler must:

1. ¶2 **Select the reference condition** from the SEEA EA framework in Section 3.4.2 — for a natural ecosystem, an undisturbed or minimally-disturbed, historical, least-disturbed or contemporary condition — and record it separately from the method used to estimate it
2. ¶3 **Justify the choice** based on data availability, scientific understanding, and policy requirements
3. ¶4 **Document the reference value** with its source and any assumptions
4. ¶5 **Establish polarity** (whether high measured values indicate high or low condition) following the polarity decision protocol described in Section 3.4.1

¶6 The strengths and limitations of each reference type for ocean accounting are summarised in Section 3.4.2. Climate-related considerations for reference condition selection are discussed in Section 3.4.2.

Step 4: Compute indicators

¶1 Normalise each variable using the min–max rescaling formula described in Section 3.4.1. The computation should be performed for each condition variable, for each ecosystem asset or spatial unit, and for both opening and closing accounting periods. The results populate the ecosystem condition indicator account, enabling comparison across variables, ecosystem types, and time periods.

Step 5: Validate indicators

DRAFT

¶1 Before aggregation, individual indicators should be validated to ensure they produce reasonable results. Validation checks include:

- ¶2 **Range check**: All indicator values should fall within [0, 1] unless deliberately allowed to exceed reference condition
- ¶3 **Consistency check**: Indicators derived from the same underlying process (e.g., coral cover and reef structural complexity) should show correlated patterns
- ¶4 **Sensitivity check**: Indicators should respond to known pressures or management interventions in expected directions
- ¶5 **Comparison with external assessments**: Where available, indicators should be compared with independent condition assessments from scientific literature or management reports

¶6 Indicators that fail validation checks should be investigated before aggregation. Common issues include incorrect reference condition selection, data entry errors, or inappropriate choice of variable for the ecosystem type.

Step 6: Aggregate into composite indices (optional)

¶1 Choose an aggregation method following the criteria in Section 3.4.3. The SEEA EA describes aggregation as optional but notes that composite indices are often required for policy communication[16]. Aggregation can occur at several levels: across indicators within the same ECT class (e.g., a composite structural state index for coral reefs), across all ECT classes for a single ecosystem type (e.g., an overall coral reef condition index), or across ecosystem types for the entire accounting area (e.g., a national marine ecosystem condition index). Higher levels of aggregation increase communication efficiency but reduce transparency and may mask critical thresholds in specific characteristics or ecosystem types.

Step 7: Disseminate with metadata

¶1 The final compilation step is to package indicators with full metadata and disseminate them to intended users. Table 3.2.2 below summarises the metadata elements that should accompany every published indicator.

DRAFT

Metadata Element	Description
Source accounts	Which extent and condition accounts provided the underlying data.
Reference conditions	What reference type and values were used for each variable.
Normalisation method	The formula and parameters used to transform variables to indicators.
Aggregation method	If composite indices were created, how indicators were weighted and combined.
Polarity decisions	The polarity assigned to each variable and the rationale, particularly for contextually ambiguous variables.
Spatial coverage	The proportion of the accounting area covered by observed versus imputed condition values, the imputation method applied, and whether a quality flag has been applied (see Section 3.6.1).
Uncertainty	Confidence intervals, data quality ratings, and sensitivity to methodological choices.
Limitations	What the indicator does and does not capture, and appropriate uses.

¶2 **Indicator versioning:** All published indicators must carry a version number and release date. When a revision is made, the nature of the revision must be classified as:

- ¶3 **Type 1** – data correction (source data corrected after publication)
- ¶4 **Type 2** – reference condition update (reference values revised following new scientific assessment)
- ¶5 **Type 3** – methodology change (normalisation formula, aggregation method, or classification scheme revised)

¶6 Revisions that affect trend direction or cross a policy threshold (for example, a change that moves MPA condition from above to below a management target) require a revision note in the metadata and back-casting of the affected time series. This revision classification approach follows standard national statistics revision policy and ensures that changes to published figures can be traced and explained [13].

3.3 Extent-Based Indicators

¶1 Extent-based indicators measure the spatial dimension of marine ecosystems: where they are, how much area they cover, and how coverage is changing over time.

3.3.1 Ecosystem extent change

¶1 The primary extent indicator is change in ecosystem extent over the accounting period, measured in absolute terms (hectares gained or lost) or relative terms (percentage change from opening extent) [17]. For marine ecosystems, extent change indicators capture:

- ¶2 Loss of ecosystem area due to conversion, degradation, or sea-level change
- ¶3 Gain of ecosystem area due to expansion, restoration, or natural succession
- ¶4 Net change combining losses and gains

¶5 The SEEA EA recommends recording extent changes through a structured account that distinguishes managed and natural drivers of change [18]. The ecosystem extent account structure records opening extent, additions (managed expansion, natural expansion), reductions (managed reduction, natural reduction), and closing extent. This structure enables indicators to distinguish anthropogenic drivers (e.g., coastal development converting mangroves) from natural processes (e.g., storm damage to coral reefs).

¶6 For ocean accounting, priority extent indicators include:

Ecosystem Type	Indicator	Data Source
Coral reefs	Reef area (km²) and change	Remote sensing, field surveys
Seagrass meadows	Meadow extent (ha) and change	Remote sensing, in situ mapping
Mangrove forests	Forest area (ha) and change	Satellite imagery, land cover mapping
Kelp forests	Canopy extent (ha) and change	Remote sensing, dive surveys
Salt marshes	Marsh area (ha) and change	Coastal mapping, remote sensing
Offshore waters	Area by water column depth zone	Bathymetry, oceanographic data

DRAFT

¶7 Thematic circulars provide detailed guidance on extent accounting for specific ecosystem types: **TG-6.1 Coral Reef Accounts**, **TG-6.2 Mangrove and Coastal Wetland Accounting**, **TG-6.3 Seagrass Accounts**, and **TG-6.5 Pelagic and Open Ocean Accounts**.

3.3.2 Ecosystem conversion

¶1 Beyond net extent change, conversion indicators track the transformation of one ecosystem type into another [19]. The ecosystem type change matrix records flows between ecosystem types, enabling construction of indicators such as:

- ¶2 Area of natural ecosystems converted to artificial or managed types (e.g., mangrove to aquaculture pond)
- ¶3 Area restored from degraded to natural condition
- ¶4 Area of coastal land converted to marine area (coastal erosion) or vice versa (land reclamation)

¶5 Conversion indicators are particularly important for understanding the drivers of extent change and the implications for ecosystem services. Conversion of mangroves to aquaculture ponds, for

example, involves loss of coastal protection and carbon storage services even if total coastal ecosystem extent is maintained through expansion elsewhere. These service implications are addressed in **TG-2.4 Ecosystem Goods and Services**.

¶6 The SEEA EA defines ecosystem conversion as occurring when "for a given location, there is a change in ecosystem type involving a distinct and persistent change in ecological structure, composition and function" [20]. For marine ecosystems, determining when a change in condition constitutes conversion to a different ecosystem type (rather than degradation within the same type) requires careful application of this standard.

¶7 **Conversion versus degradation decision framework:** A compiler should assess conversion when condition evidence suggests a persistent change in ecological structure, composition, and function consistent with SEEA EA para 4.23, confirmed over at least two consecutive accounting periods. A change is considered distinct if it is assessed as not reversible within the normal accounting cycle, based on condition evidence documented in the ecosystem condition account. This determination cannot rest on a single condition metric or a fixed numerical threshold. Instead, the compiler must document the specific condition metric(s) and decision criterion used, drawing on local reference distributions or national ecological assessment standards. Any reclassification from degradation to conversion must be submitted to national technical committee approval before being recorded in the extent account. Guidance on marine ecosystem classification is provided in **TG-3.1 Asset Accounts** and **TG-0.2 Standards Overview** [21].

3.3.3 Extent indicators for policy targets

¶1 Extent indicators align directly with international policy targets. SDG target 14.5 set a 2020 deadline for conserving at least 10% of coastal and marine areas, measured by indicator 14.5.1 (coverage of protected areas in relation to marine areas) [22]. The Kunming-Montreal Global Biodiversity Framework Target 3 has since set a more ambitious target of protecting at least 30% of marine areas by 2030 [23]. Extent accounts for marine protected areas, combined with condition accounts assessing protection effectiveness, provide the 'data foundation' for national reporting against these targets. The application of ocean accounts to MPA assessment is addressed in detail in **TG-1.3 OA and Marine Spatial Management**.

¶2 SDG 15.3.1 measures land degradation, including coastal areas, through an approach that integrates extent and condition information [24]. This methodology could be extended to marine ecosystems as "ecosystem degradation neutrality" indicators — the degraded-area classification for GBF Target 2 in **TG-2.10** Section 3.3 is the nearest existing guidance for marine contexts.

3.4 Condition-Based Indicators

3.4.1 Deriving condition indicators from variables

¶1 **Reference condition parameters:** The following definitions apply throughout this section and in the normalisation formula:

- ¶2 **Reference condition** (general concept) — the benchmark state of the ecosystem used to contextualise current condition. For a natural ecosystem SEEA EA offers an undisturbed or minimally-disturbed, historical, least-disturbed or contemporary condition; anthropogenic ecosystems draw on a separate set ending in best-attainable condition (see Section 3.4.2, which is normative).
- ¶3 **U (upper reference value)** — the formula parameter representing good condition. This is the value of the condition variable associated with the chosen reference condition.
- ¶4 **L (lower reference value)** — the formula parameter representing degraded condition. This is the minimum acceptable or fully degraded value of the condition variable.

¶5 The transformation from condition variables to condition indicators involves normalisation against these reference levels. The SEEA EA describes a linear transformation approach [25]:

¶6 **Indicator = (Variable value − L) / (U − L)**

¶7 Where U is the upper reference value (high condition) and L is the lower reference value (degraded condition). The resulting indicator takes values between 0 (fully degraded) and 1 (reference condition). Any reference type (natural, historical, policy target, or best observed) may serve as U, provided the compiler documents the choice in Step 7 metadata.

¶8 For some variables, high measured values indicate high condition (e.g., species richness, coral cover), whilst for others, high measured values indicate low condition (e.g., pollutant concentration, invasive species abundance). The polarity of the transformation must be adjusted accordingly to ensure consistent interpretation of indicator values [26]. The inverse-polarity formula is:

¶9 **Indicator = (L − Variable value) / (L − U)**

¶10 **Polarity decision protocol:** Compilers must assign a polarity (Normal or Inverse) to each condition variable before computing indicators and record this assignment in Step 7 metadata. The following decision sequence should be applied:

1. ¶11 If the variable has a clear monotonic relationship with ecosystem health in the target ecosystem type (e.g., coral cover: more = better), assign Normal or Inverse polarity accordingly.
2. ¶12 If the variable has context-dependent polarity, consult the reference table below for the recommended default and note any override with justification.
3. ¶13 If polarity cannot be determined from published ecological evidence, flag the variable as requiring expert review before publication.

Variable	Recommended Default Polarity	Notes on Override
Chlorophyll-a concentration	Inverse (eutrophication indicator)	Override to Normal if used as primary productivity proxy in oligotrophic open-ocean systems; document context
Turbidity	Inverse (reduces light penetration)	Override to Normal in estuarine nursery habitats where moderate turbidity supports feeding; document context
Dissolved inorganic nitrogen	Inverse	No standard override
Water temperature	Inverse (thermal stress context)	Override to Normal in cold-water ecosystems where warming improves productivity; document context

DRAFT

¶14 **Example (normal polarity)**: For a coral reef ecosystem, coral cover percentage might be transformed as follows:

- ¶15 U (upper reference, high condition): 50% coral cover
- ¶16 L (lower reference, degraded condition): 5% coral cover
- ¶17 Observed value: 35% coral cover
- ¶18 Indicator = (35 − 5) / (50 − 5) = 30 / 45 = 0.67

¶19 This indicator value of 0.67 indicates the coral reef is at 67% of reference condition based on the coral cover characteristic.

¶20 **Example (inverse polarity)**: For a coastal water body, dissolved inorganic nitrogen concentration is an inverse indicator: higher values indicate lower condition. The transformation adjusts polarity accordingly:

- ¶21 U (upper reference, high condition): 0.1 mg/L (low nutrient level characteristic of unpolluted waters)
- ¶22 L (lower reference, degraded condition): 1.5 mg/L (eutrophic level)
- ¶23 Observed value: 0.6 mg/L
- ¶24 Indicator = (L − Observed) / (L − U) = (1.5 − 0.6) / (1.5 − 0.1) = 0.9 / 1.4 = 0.64

¶25 This indicator value of 0.64 indicates the water body is at 64% of reference condition based on nutrient concentration, with the inverse polarity ensuring that lower pollutant levels correspond to

higher indicator scores.

¶26 **Variables measured on a logarithmic scale**

¶27 The linear transformation above assumes that equal changes in the variable represent equal changes in condition. That assumption fails for variables measured on a logarithmic scale, of which pH is the case most often encountered in ocean accounts. A shift from pH 8.2 to pH 8.0 is a rise of roughly 58 per cent in hydrogen ion concentration, yet the linear transformation registers it as a small deviation and understates the ecological significance of acidification.

¶28 For pH, compilers should therefore apply a **categorical step deduction** in place of the linear formula:

¶29 **Indicator = 1.00 − (0.10 x n)**, where **D** is the deviation in pH units below the reference value and **n** is the number of complete 0.05-unit steps in **D** − that is, the largest integer satisfying **n x 0.05 <= D**.

¶30 The indicator is clamped at 0 and capped at 1.00 where observed pH equals or exceeds the reference. The resulting bands are:

Deviation below reference (D)	Indicator
D < 0.05	1.00
0.05 <= D < 0.10	0.90
0.10 <= D < 0.15	0.80
0.15 <= D < 0.20	0.70
0.20 <= D < 0.25	0.60
each further 0.05	deduct a further 0.10, to a floor of 0

¶31 **A note for implementers.** Determine *n* by comparison in whole hundredths of a pH unit, not by floating-point division. In IEEE-754 double precision `0.15 / 0.05` evaluates to 2.9999999999999996, so a literal `floor(D / 0.05)` returns 2 and yields 0.80 where the band table gives 0.70 − and D = 0.15 is a value that occurs in the worked example in TG-1.3 Section 3.6.

¶32 *Example*: reference pH 8.2, observed pH 8.03. D = 0.17, which contains three complete 0.05-unit steps (0.15 <= 0.17 < 0.20), so n = 3 and the indicator = 1.00 − 0.30 = **0.70**.

¶33 Compilers should document the reference pH value, its source (historical baseline, pristine-site comparison, or ecological modelling), and the step size applied. Where a national programme has evidence supporting a different step size, it may be substituted provided the choice is documented and applied consistently across periods.

¶34 This treatment is applied to the pH rows of the marine protected area condition accounts in **TG-1.3 OA and Marine Spatial Management** Section 3.6.

3.4.2 Reference conditions

¶1 The choice of reference condition is one of the most consequential methodological decisions in condition indicator construction. Reference conditions establish the benchmark against which current ecosystem state is measured [15]. SEEA EA Appendix A5.2 separates two decisions that this Circular previously ran together, and they are chosen independently of one another:

- ¶2 **which state** is taken as the benchmark − the *reference condition*; and
- ¶3 **how that state is quantified** − the *estimation method*.

¶4 The axes are orthogonal. A historical reference condition may be quantified from palaeo-environmental data, from a model, from expert opinion, or from a combination of these. Treating an estimation method as though it were a kind of reference condition produces reference levels that cannot be documented against the standard, because the two are recorded separately.

¶5 **The natural state is the recommended default.** SEEA EA takes the reference condition to be the state at which ecological integrity is maximal, and states that using the natural state "is preferred and recommended" (para 5.70)[15]. The benchmark is deliberately independent of management objectives: the natural state "may not be related to supply of ecosystem services and may not be the target of current legislation, policy or ecosystem management objectives" (para 5.69). Measuring distance from the natural state is what allows the degree of ecosystem change to be seen at all.

¶6 **Table 3.4.2: Assessment framework for selecting a reference condition**, reproduced from SEEA EA Table A5.2.1[27]

Ecosystem class	Reference condition	Definition
Natural	Undisturbed or minimally-disturbed	The condition of an intact ecosystem with maximal ecological integrity and no or minimal disturbance.
Natural	Historical	The condition at some point or period in its history considered to represent the stable natural state — for example the pre-industrial period.
Natural	Least-disturbed	The currently best available condition of the ecosystem.
Natural	Contemporary	The condition at a point or period in its recent history for which comparable data are available.
Anthropogenic	Historical	As above, but representing the stable *socio-ecological* state.
Anthropogenic	Least-disturbed	The currently best available condition of the ecosystem.
Anthropogenic	Contemporary	The condition at a point or period in its recent history for which comparable data are available.
Anthropogenic	Best-attainable	The expected condition under best possible management practices, attaining a stable socio-ecological state.

¶7 Natural ecosystems are those predominantly influenced by natural ecological processes, whose condition ranges within its natural variability; anthropogenic ecosystems are those predominantly influenced by human activities, where a stable natural state is unobtainable. In **semi-natural or lightly managed** ecosystems any of the five conditions may be used, provided the choice is explicit and its rationale explained.

¶8 Two consequences follow for marine accounts. First, coral reef, seagrass, mangrove, kelp forest, pelagic and deep-sea systems are **natural** ecosystems under SEEA EA, so the four natural-ecosystem conditions are the ones available to them; **best-attainable condition is not**, being confined to anthropogenic systems such as artificial waterbodies and other anthropogenic marine systems. Second, each of the four is a *state of the ecosystem*, not a management objective.

¶9 **Table 3.4.3: Methods for estimating a reference condition**, reproduced from SEEA EA Table A5.2.2[28]

¶10 A mark indicates that the method can be used to estimate that reference condition.

Estimation method	Undisturbed / minimally-disturbed	Historical	Least-disturbed	Contemporary	Best-attainable
1. Reference sites	x	x	x	x	
2. Modelled reference conditions	x	x	x		x
3. Statistical approaches based on ambient distributions			x		x
4. Historical observations and palaeo-environmental data		x			

DRAFT

Estimation method	Undisturbed / minimally-disturbed	Historical	Least-disturbed	Contemporary	Best-attainable
5. Contemporary data				x	
6. Prescribed levels					x
7. Expert opinion	x		x		x

¶11 Method 8 is a combination of the above and is not a separate column. SEEA EA directs that **methods 1–4 are considered first**, as the approaches that best describe and quantify the reference condition and the upper and lower reference levels. Methods 5–7 are alternatives where methods 1–4 cannot be applied, or where policy or legislative drivers require method 5 or 6. Method 7 is noted as particularly relevant to capturing Indigenous knowledge and perspectives; where it is used, the consent, attribution and data-governance requirements in **TG-3.6 Traditional Knowledge** apply.

¶12 **Where a policy target sits.** Prescribed levels — method 6 — estimate only the best-attainable condition, and best-attainable is available only to anthropogenic ecosystems. A level prescribed in policy or legislation therefore has no cell in the natural-ecosystem columns of Table 3.4.3. SEEA EA makes the same point from the other direction: globally agreed reference conditions support comparison between countries, but "some of these reference conditions may incorporate aspects concerning policy targets and hence may not fully reflect the conceptual basis for a reference condition for ecosystem accounting" (para 5.73). Section 3.4.1 permits any reference type to serve as U provided the choice is documented; where that type is a policy target applied to a natural ecosystem, compilers should record it as a departure from Table 3.4.2 and state the reason, so that the series can be reconciled if the target is later revised.

¶13 The SEEA EA emphasises that reference conditions should be "clearly defined, scientifically based, and consistent with the purpose of the assessment"[29]. For marine ecosystems, establishing natural reference conditions is particularly challenging due to the long history of human fishing pressure and the "shifting baseline syndrome" whereby each generation accepts the degraded state they first observe as normal[30].

¶14 For marine ecosystems subject to climate change, reference conditions may need to incorporate considerations of climate adaptation and novel ecosystem states, and a reference condition that is periodically updated against monitored reference sites is one way SEEA EA contemplates handling this.

¶15 Climate change introduces a methodological challenge for reference condition selection. Fixed reference conditions (whether natural or historical) enable tracking of total change in ecosystem state, including climate-driven change, and support assessment of cumulative human impact. Adjusted reference conditions that account for inevitable climate-driven shifts enable assessment of the additional impact of local pressures beyond background climate change. In practice, compilers may present both fixed and adjusted reference conditions in parallel, allowing users to distinguish between total change and locally manageable change.

¶16 **Climate adjustment decision box:** When a compiler chooses to use an adjusted reference condition to account for climate change, the following specifications apply:

- ¶17 **Recommended scenario**: SSP2-4.5 (intermediate emissions pathway) is the default. Where a country has adopted a specific national NDC scenario for official environmental reporting, that scenario may be used as an alternative with documented justification.
- ¶18 **Adjustment time horizon**: The baseline-period median projected change to the accounting year, derived from the selected scenario.
- ¶19 **Acceptable data sources**: CMIP6 multi-model ensembles are the primary source, whilst downscaled regional climate model outputs are acceptable where available and peer-reviewed.

DRAFT

- ¶20 **Step 7 metadata record (mandatory)**: The scenario identifier, data source citation, and the numerical adjustment value applied to each reference condition must be recorded and published with the indicator.

¶21 Where adjusted reference conditions are used, these specifications must be followed to enable comparison across assessments and time periods.

3.4.3 Condition indices

¶1 Ecosystem accounts connect extent, condition, services in physical and monetary terms, and monetary asset accounts. Those connections illustrate why condition indices occupy a central position in the accounting framework. Condition accounts both depend on extent information and inform the measurement of ecosystem services, creating an integrated chain of measurement.

¶2 Figure 2.1.3 shows the connections between ecosystem accounts (adapted from 2025 SNA Figure 35.3)[31].

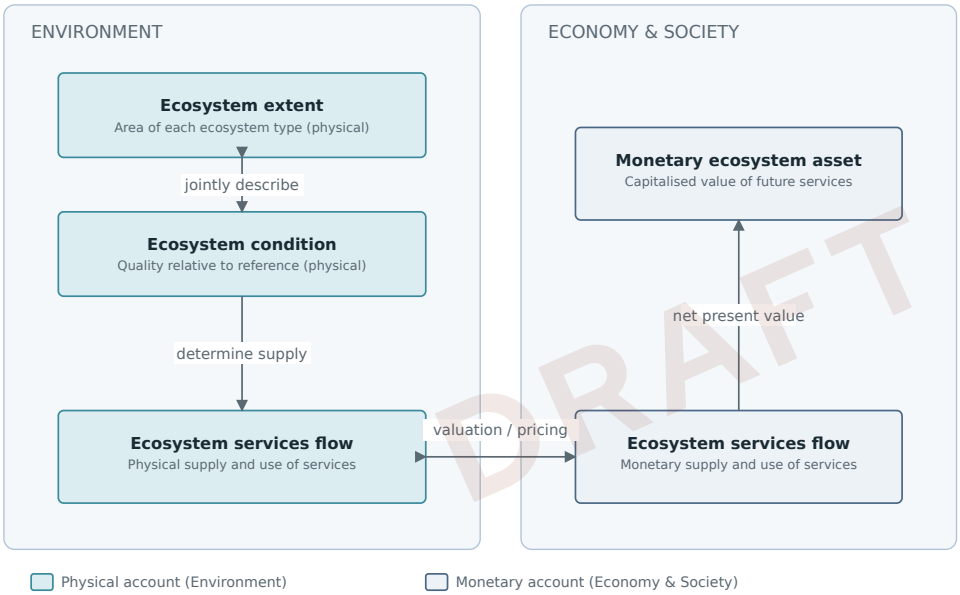


Figure 2.1.3 Five SEEA EA ecosystem accounts connect: extent and condition determine physical service flows that value into monetary accounts. Physical flows link by valuation to monetary service flows, which accumulate as NPV into the monetary asset account.

¶3 Ecosystem condition indices aggregate individual condition indicators into composite measures that summarise overall ecosystem health[16]. Index construction involves decisions about which indicators to include, how to weight them, and what aggregation function to apply.

¶4 **Arithmetic mean**: The simplest aggregation approach, giving equal weight to all included indicators. An ecosystem condition index calculated as the arithmetic mean of n indicators would be:

¶5 **ECI = (1/n) x Sum of all indicator values**

¶6 This approach is transparent and easy to calculate but assumes substitutability between indicators: improvement in one characteristic can compensate for decline in another.

¶7 **Geometric mean**: Gives more emphasis to low values, such that a low score on any indicator reduces the overall index substantially. This approach reflects the view that ecosystem health

requires adequate performance across all characteristics, with weak-link characteristics constraining overall condition.

¶8 **Weighted mean**: Assigns different weights to indicators based on their importance for ecosystem function, data quality, or policy relevance. Weighting can be based on expert elicitation, statistical approaches (e.g., principal components analysis), or ecosystem modelling. Weights should be transparent and justified [32]. For a set of n indicators with weights w_i summing to 1, the weighted mean ECI is:

¶9 **ECI = Sum of (w_i x Indicator_i) for i = 1 to n**

¶10 The structure of ecosystem condition accounting described in SEEA EA allows for aggregation in several ways: across indicators within the same ECT class, across classes of characteristics in the ECT, or across ecosystem types [33]. For example:

- ¶11 An aggregate index for "structural state" of coral reefs (combining coral cover, rugosity, colony size distribution)
- ¶12 An overall condition index for coral reefs (combining structural, compositional, physical, chemical, functional, and seascape indicators)
- ¶13 A national marine ecosystem condition index (combining condition indices for coral reefs, seagrass, mangroves, and other marine ecosystem types, weighted by area)

¶14 The SEEA EA notes that "where it is undertaken, a clear link should be established to information on movements in individual indicators" [34]. That link ensures that aggregate indices do not obscure important changes in component variables.

3.5 Worked Example: Coastal Ecosystem Condition Indicators

¶1 This section presents a worked example demonstrating how to compile and aggregate biophysical indicators for a hypothetical coastal area. The example uses synthetic data for two marine ecosystem types (mangroves and coral reefs) to illustrate the compilation procedure described in Section 3.2 and the normalisation and aggregation methods presented in Sections 3.3 and 3.4. All indicator values are rounded to two decimal places using standard rounding.

DRAFT

Scenario description

¶1 The accounting area is a coastal zone containing 450 km² of mangrove forest and 180 km² of coral reef ecosystems. The accounting period is calendar year 2025. Condition monitoring data were collected at 25 field sites (15 mangrove, 10 reef) distributed across the accounting area, with quarterly sampling throughout the year.

Step 1: Source data from condition accounts

¶1 Condition variable data were extracted from the ecosystem condition variable accounts compiled following **TG-3.1 Asset Accounts**. Table 1 presents selected condition variables for mangroves, with values at the opening (January 2025) and closing (December 2025) of the accounting period.

¶2 *Table 1: Ecosystem condition variables for mangroves, 2025*

ECT Class	Variable	Polarity	Unit	Opening Value	Closing Value	Upper Reference (U)	Lower Refere (L)
A1 Physical	Sedimentation rate	Inverse	mm/yr	3.2	3.5	2.0	5.0
A2 Chemical	Soil salinity	Inverse	PSU	18	19	15	25
B1 Compositional	Tree species richness	Normal	count	8	8	12	4

ECT Class	Variable	Polarity	Unit	Opening Value	Closing Value	Upper Reference (U)	Lower Refere (L)
B2 Structural	Canopy density	Normal	% cover	72	70	85	40
B3 Functional	Leaf litter production	Normal	g/m²/yr	480	465	550	200
C Seascape	Connectivity index	Normal	0-1	0.68	0.65	0.80	0.30

¶3 Table 2 presents condition variables for coral reefs:

¶4 *Table 2: Ecosystem condition variables for coral reefs, 2025*

ECT Class	Variable	Polarity	Unit	Opening Value	Closing Value	Upper Reference (U)	Lo Re (L
A1 Physical	Water tempera-ture	Inverse	C	27.2	27.8	26.5	30
A2 Chemical	pH (ocean acidifica-tion)	Normal	pH units	8.05	8.03	8.20	7.9
B1 Compositional	Coral species richness	Normal	count	42	41	60	20
B2 Structural	Live coral cover	Normal	% cover	35	32	50	10
B3 Functional	Recruitment rate	Normal	recruits/m²/yr	12	11	20	5
C Seascape	Reef connectivity	Normal	index 0-1	0.52	0.50	0.75	0.3

DRAFT

Step 2: Apply reference conditions and compute indicators

¶1 For each variable, indicators were computed using the linear normalisation formula described in Section 3.4.1 with U (upper reference) and L (lower reference) as defined in Table 1 and Table 2. The exception is pH, which takes the categorical step deduction in Section 3.4.1 against the reference pH of 8.20: D = 0.15 at opening and 0.17 at closing, so n = 3 in both periods and the indicator is 0.70 in both.

¶2 For variables with normal polarity (higher values = better condition): **Indicator = (Observed – L) / (U – L)**

¶3 For variables with inverse polarity (higher values = worse condition): **Indicator = (L – Observed) / (L – U)**

¶4 *Table 3: Mangrove condition indicators, 2025 (indicator values, 0–1 scale)*

ECT Class	Variable	Opening Indicator	Closing Indicator	Change
A1 Physical	Sedimentation rate	0.60	0.50	-0.10
A2 Chemical	Soil salinity	0.70	0.60	-0.10
B1 Compositional	Species richness	0.50	0.50	0.00
B2 Structural	Canopy density	0.71	0.67	-0.04
B3 Functional	Leaf litter production	0.80	0.76	-0.04
C Seascape	Connectivity	0.76	0.70	-0.06

¶5 *Table 4: Coral reef condition indicators, 2025 (indicator values, 0–1 scale)*

ECT Class	Variable	Opening Indicator	Closing Indicator	Change
A1 Physical	Temperature stress	0.80	0.63	-0.17
A2 Chemical	Ocean pH	0.70	0.70	0.00
B1 Compositional	Species richness	0.55	0.53	-0.02
B2 Structural	Coral cover	0.63	0.55	-0.08
B3 Functional	Recruitment	0.47	0.40	-0.07
C Seascape	Connectivity	0.54	0.50	-0.04

¶6 **Interpretation**: Both ecosystem types record declining condition across most indicators during 2025. Mangrove condition declined moderately, with the largest decreases in sedimentation rate (increased sediment loading) and soil salinity (increased salinity stress). Coral reef condition also declined, with the largest decrease in the temperature stress indicator, where warming water temperatures approached bleaching thresholds.

Step 3: Aggregate into composite condition indices

¶1 Composite condition indices were calculated for each ecosystem type using three aggregation methods to illustrate their differences:

¶2 **Arithmetic mean**: Simple average of all six indicators **Geometric mean**: nth root of the product of all indicators **Weighted mean**: Weighted average with structural state (B2) receiving double weight (reflecting its importance for ecosystem services), giving weight vector w = [1/7, 1/7, 1/7, 2/7, 1/7, 1/7] for the six indicators in the order A1, A2, B1, B2, B3, C.

¶3 The weighted mean ECI for each ecosystem type and period is computed as:

¶4 **ECI = (w_A1 x I_A1) + (w_A2 x I_A2) + (w_B1 x I_B1) + (w_B2 x I_B2) + (w_B3 x I_B3) + (w_C x I_C)**

¶5 For coral reefs opening: (1/7 x 0.80) + (1/7 x 0.70) + (1/7 x 0.55) + (2/7 x 0.63) + (1/7 x 0.47) + (1/7 x 0.54) = (0.80 + 0.70 + 0.55 + 1.26 + 0.47 + 0.54) / 7 = 4.32 / 7 = 0.62.

¶6 *Table 5: Composite ecosystem condition indices for mangroves and coral reefs, 2025*

Aggregation Method	Mangroves Opening	Mangroves Closing	Coral Reefs Opening	Coral Reefs Closing
Arithmetic mean	0.68	0.62	0.62	0.55
Geometric mean	0.67	0.61	0.61	0.54
Weighted mean (B2 x2; w = [1/7, 1/7, 1/7, 2/7, 1/7, 1/7])	0.69	0.63	0.62	0.55

¶7 **Interpretation**: All three aggregation methods produce similar results. Each indicates a condition decline for both ecosystem types. The geometric mean produces slightly lower values than the arithmetic mean, as it places more emphasis on low-scoring indicators. The weighted mean that emphasises structural state produces values equal to or slightly higher than the arithmetic mean and is consistent with the stated weight vector.

Step 4: Calculate realm-specific and area-weighted condition indices

¶1 Under the IUCN Global Ecosystem Typology v2.1, mangroves belong to the Marine Freshwater-Terrestrial (MFT) realm and coral reefs belong to the Marine realm. Because the SEEA EA (para 5.87) cautions against aggregation across ecosystem types from different realms, compilers should present condition indices by realm as their primary outputs. Cross-realm aggregation requires explicit documentation of purpose and limitations.

DRAFT

¶2 **Separate realm indices (primary output):**

- ¶3 MFT realm (mangroves only): Opening ECI = 0.68, Closing ECI = 0.62
- ¶4 Marine realm (coral reefs only): Opening ECI = 0.62, Closing ECI = 0.55

¶5 **Cross-realm combined index (illustrative; for use only when explicitly documented):**

¶6 When a single national marine summary is required for state-of-environment reporting, an area-weighted aggregate may be computed alongside the separate realm indices:

¶7 **National Marine ECI = (Extent_mangroves x ECI_mangroves + Extent_coral x ECI_coral) / Total Marine Extent**

¶8 Using the arithmetic mean indices and extent values:

- ¶9 Mangroves: 450 km² x 0.62 = 279
- ¶10 Coral reefs: 180 km² x 0.55 = 99
- ¶11 Total: (279 + 99) / (450 + 180) = 378 / 630 = **0.60**

¶12 Compilers presenting a cross-realm combined index must document: (a) the realm classification of each ecosystem type, (b) the specific purpose for which the combined index is required, and (c) the limitation that the aggregate conceals divergent trends across realms. The separate realm indices must be published alongside the combined figure.

Step 5: Link to extent indicators and policy targets

¶1 The worked example can be extended to link condition indicators with extent indicators to assess progress toward policy targets. If the accounting area's marine protected area (MPA) coverage target is 30% by 2030 (following the Kunming-Montreal Global Biodiversity Framework Target 3), and current MPA coverage is 25% (158 km² of the 630 km² total marine area), the question arises: is the protected area in good condition?

¶2 Cross-tabulating MPA coverage with ecosystem condition reveals:

¶3 *Table 6: MPA coverage by ecosystem type and condition status*

Ecosystem Type	Total Extent (km²)	MPA Extent (km²)	MPA Coverage (%)	Avg Condition in MPAs	Avg Condition Outside MPAs
Mangroves	450	115	26%	0.68	0.60
Coral reefs	180	43	24%	0.60	0.53
Total	**630**	**158**	**25%**	**0.66**	**0.58**

¶4 **Note on derivation of Table 6 condition values**: The average condition within and outside MPAs is computed by spatially disaggregating the condition variable accounts to MPA polygon boundaries and computing separate area-weighted condition indices for each spatial stratum. The "Avg Condition in MPAs" values therefore require that condition data are available at a spatial resolution finer than the MPA boundary. For coral reefs, the area-weighted check is: (43 x 0.60 + 137 x 0.53) / 180 = (25.80 + 72.61) / 180 = 98.41 / 180 = 0.55, consistent with the whole-ecosystem closing ECI.

¶5 **Interpretation**: The accounting area has achieved 25% MPA coverage, approaching the 30% target. Ecosystems within MPAs exhibit better condition than those outside (average ECI 0.66 vs 0.58). This gap points to a positive effect of protection. Even protected ecosystems, however, remain well below reference condition (0.66 vs 1.0): MPA designation alone is insufficient to maintain ecosystem health, and broader pressures such as climate change and upstream pollution also require management. This analysis demonstrates how aggregate indicators derived from accounts can inform policy discussions about the quality of protection, and not area alone.

DRAFT

Analytical insights

¶1 This worked example illustrates several key features of aggregate indicator compilation:

1. ¶2
   Transparency and comparability: Normalised indicators improve both transparency and cross-ecosystem comparability by exposing the underlying reference conditions and aggregation choices, enabling traceability from headline index to source condition variable.
2. ¶3
   Aggregation sensitivity: Different aggregation methods produce similar but not identical results. That divergence points to the importance of documenting and justifying the chosen approach.
3. ¶4
   Policy relevance: The linked analysis of MPA coverage and condition demonstrates how aggregate indicators can directly inform questions about conservation effectiveness and target achievement.
4. ¶5
   Communication efficiency: The separate realm indices and the illustrative combined national ECI of 0.60 together serve different audiences: technical analysts can investigate realm-specific trends whilst non-technical audiences receive an accessible headline figure.

3.6 Aggregation Approaches

3.6.1 Spatial aggregation

¶1 Spatial aggregation combines condition indicators from individual ecosystem assets or grid cells into summary measures for larger areas such as management zones, provinces, or entire countries. Key considerations include:

¶2 **Area weighting**: Larger ecosystem assets should typically contribute more to aggregate indicators than smaller assets. The standard approach weights each unit's condition score by its area (area-weighting formula: Section 3.5 Step 4)[35]. This area-weighted approach ensures that the aggregate indicator reflects conditions across the full spatial extent of the ecosystem type.

¶3 **Default aggregation method**: Where data or policy requirements do not indicate otherwise, the **arithmetic mean** of the component indicators is the default method for combining condition indicators within an ecosystem type. Section 3.4.3 and the worked example in Section 3.5 Step 3 set out the geometric and weighted alternatives and their implications for interpretation. Compilers should state which method has been applied wherever a composite index is published.

¶4 **Sub-account aggregation within a single accounting area**: Where an accounting area contains more than one habitat type — for example a marine protected area holding coral reef, seagrass and pelagic sub-accounts — the area-level index is the area-weighted mean of the sub-type indices:

¶5 **Area ECI = Sum over sub-types of (Sub-type ECI x Sub-type area) / Total area of the sub-types included**

¶6 Sub-type indices should be **published alongside** the area-level aggregate, not only as inputs to it. An aggregate can conceal divergent trends between habitat types that a manager needs to act on separately, and the sub-type series is the one that supports habitat-specific intervention. Where a habitat present in the accounting area is excluded from the aggregate for want of data, the excluded area and the reason should be stated with the index.

¶7 **Representativeness**: Aggregate indicators are only meaningful if the underlying spatial units adequately represent the full range of ecosystem conditions within the accounting area. Sampling bias can distort aggregate indicators, for example if monitoring sites are concentrated in accessi-

DRAFT

ble or well-managed areas. The SEEA EA recommends that "hierarchical aggregation schemes should contain a description of how missing indicators or subindices are handled" [36].

¶8 **Missing data protocol**: Compilers will routinely encounter spatial units with no condition monitoring data (for example, remote offshore reefs or areas with monitoring gaps). Where condition data are unavailable for some spatial units, the following protocol applies:

- ¶9 The compiler documents the proportion of the accounting area covered by observed versus imputed condition values in Step 7 metadata.
- ¶10 Where imputation is applied, the method and rationale must be recorded. Permissible imputation methods are: (a) carry-forward from the prior accounting period, (b) regional mean from adjacent spatial units within the same ecosystem type, and (c) spatial interpolation from neighbouring monitored units.
- ¶11 A quality flag is applied to the aggregate indicator when the imputed area exceeds the observed area (i.e., imputed proportion > 0.5 of total area). This flag signals to users that the aggregate rests primarily on estimated rather than observed values.
- ¶12 No GOAP minimum coverage threshold is prescribed. Coverage adequacy is a matter of national statistical judgment. Compilers must document their assessment of whether the observed coverage is sufficient to support the published aggregate and communicate limitations transparently.

¶13 **Connectivity**: For some purposes, spatially connected ecosystem assets may warrant different aggregation treatment than fragmented assets. Landscape/seascape indicators that capture connectivity and fragmentation can complement simple area-weighted aggregation.

¶14 Spatial considerations for marine ecosystems are addressed in more detail in **TG-4.1 Remote Sensing Data** and **TG-4.3 Geospatial Data Integration**.

3.6.2 Projecting a condition trajectory under a management scenario

¶1 Scenario analysis in planning and appraisal circulars requires a projected condition index, not only an observed one. Accounts do not record the immediate effect of a management action: the efficacy of a decision becomes visible over successive accounting periods as the condition variables are re-measured, and for many marine ecosystems a change in the composite index takes three to five years or more to emerge. Projection is therefore a modelling step layered on the accounts, and its outputs must be labelled as projections rather than account entries.

¶2 The procedure is:

1. ¶3 Identify the primary pressure that the management action addresses (fishing pressure, sediment input, thermal stress, nutrient loading).
2. ¶4 Select the condition variables most sensitive to that pressure — for fishing pressure, compositional state variables such as fish community diversity, and structural state variables such as coral cover or seagrass canopy height.
3. ¶5 Estimate the expected rate of change in each selected variable per accounting period under the proposed regime, from ecological recovery literature or from regional time series for comparable sites.
4. ¶6 Apply the per-period rate to derive a projected trajectory for each variable across the scenario horizon.
5. ¶7 Normalise each projected variable value against its upper and lower references (Section 3.4.1) and aggregate to a composite index for each period using the method in Section 3.6.1.
6. ¶8 Record the projected index values as the scenario condition trajectory, with an uncertainty range, and state that actual condition change will be verified through successive account compilations.

DRAFT

¶9 Variables that respond on different timescales should not be projected on a common rate. Structural complexity and apex predator recovery lag compositional measures substantially, and a composite projected from a single recovery rate will overstate near-term improvement.

¶10 This procedure supports the scenario comparison in **TG-1.2 OA and Marine Spatial Planning** Section 3.5 and the sustainability scenarios in **TG-1.4 OA and Sustainable Ocean Planning** Section 3.6.

3.6.3 Temporal aggregation

¶1 Temporal aggregation produces indicators for periods longer than the basic accounting period or enables comparison across non-contiguous time points. Considerations include:

¶2 **Time series averaging**: Multi-year averages smooth short-term variability, which may obscure important trends but provides more reliable indicators when inter-annual variation is high due to natural cycles or measurement noise.

¶3 **Trend indicators**: Change over time may be more policy-relevant than absolute condition levels. Trend indicators express the rate of improvement or decline in condition, often calculated using statistical approaches such as linear regression over the available time series.

¶4 **Baseline comparison**: Indicators expressed relative to a baseline year enable tracking of progress (or regress) from a defined starting point, which is often required for policy reporting.

3.6.4 Aggregation across ecosystem types

¶1 For summary indicators at the national or regional level, aggregation across different marine ecosystem types may be desirable. The SEEA EA provides guidance on creating an overall ecosystem condition index where "aggregation can take the form of a condition index applied to each ecosystem type, weighted by the area of the ecosystem type within the EAA, then summed for all ecosystem types in the EAA to derive an overall ecosystem condition index"[37].

¶2 Combining condition indices for ecosystem types that belong to different IUCN GET v2.1 realms is discouraged unless compilers explicitly document the purpose and limitations. The primary published outputs should be separate condition indices by realm or ecosystem type. Where a cross-realm combined index is presented, compilers must state the realm classification of each contributing ecosystem type, explain why a combined figure is required, and note the limitation that the aggregate may conceal divergent trends across realms[38]. This requirement reflects SEEA EA para 5.87, which cautions against aggregation across fundamentally different ecosystem types.

¶3 Within a single realm, aggregation across ecosystem types follows the area-weighted approach described in Section 3.5 Step 4, with the same requirements for documentation, quality flags, and linkage to disaggregated component indices.

¶4 Combined presentations that integrate biophysical indicators with economic accounts are addressed in **TG-3.8 Combined Presentations**.

3.7 Marine-Specific Applications

3.7.1 Coral reef health indicators

¶1 Priority condition variables for coral reef accounts include[39]:

ECT Class	Variable	Indicator Description
Structural state	Coral cover	Live coral as % of substrate
Structural state	Rugosity	Three-dimensional complexity
Compositional state	Fish biomass	Reef fish density (kg/ha)
Compositional state	Coral diversity	Species richness, community composition

DRAFT

ECT Class	Variable	Indicator Description
Chemical state	Carbonate saturation	Aragonite saturation state
Physical state	Sea surface temperature	Thermal stress exposure
Functional state	Recruitment rate	Coral larvae settlement

¶2 Aggregate reef condition indices combine these variables with appropriate weighting. The Reef Check methodology, for example, produces summary indicators from standardised survey protocols [40]. The Ocean Health Index includes a "biodiversity" subgoal that incorporates habitat condition for coral reefs and other marine habitats [41].

¶3 Detailed guidance on coral reef accounting, including extent measurement and condition indicators, is provided in **TG-6.1 Coral Reef Accounts**.

3.7.2 Fish stock indicators

¶1 Fish stock condition provides indicators of both individual environmental asset status (treated in **TG-3.1 Asset Accounts**) and ecosystem compositional state. The SEEA EA treats fish stocks primarily as non-cultivated biological resources recorded in asset accounts [42]. Compilers should apply the following decision boundary when assigning fish-related variables to account categories:

¶2 **Decision boundary — fish stock and fish community indicators:**

- ¶3 **Asset account (not condition index)**: Fish stock status indicators based on biomass relative to reference points (B/B_MSY) and exploitation rate (F/F_MSY) belong in the ecosystem asset account and in SDG 14.4.1 reporting tables. Including these indicators in condition indices would double-count information already captured in the asset account and would introduce fisheries management performance, an outcome of human exploitation decisions, into what should be a biophysical ecosystem state measure.
- ¶4 **Condition account, B1 compositional state class**: Fish community indicators such as mean trophic level of the fish assemblage, functional diversity, and size spectrum belong in the B1 compositional state class of condition accounts. These variables characterise the ecosystem's biotic composition independent of stock-specific exploitation status.
- ¶5 **Condition account, habitat condition**: Habitat quality metrics for fish nursery areas, such as coral cover, seagrass density, and mangrove canopy density, belong in the relevant habitat condition account (coral reef, seagrass, or mangrove). These are structural state (B2) variables for those ecosystems and should not be entered as fish stock indicators.

¶6 Stock status indicators include:

¶7 **Biomass relative to reference points**: Current spawning stock biomass (B) relative to the biomass at maximum sustainable yield (B_MSY) or unfished biomass (B_0). Stocks with B > B_MSY are considered within biologically sustainable limits [43].

¶8 **Exploitation rate indicators**: Fishing mortality (F) relative to the fishing mortality at maximum sustainable yield (F_MSY). Stocks with F < F_MSY are not experiencing overfishing.

¶9 **Trophic level indicators**: Mean trophic level of fish communities, tracking changes in ecosystem structure that may indicate "fishing down the food web" [44].

¶10 SDG indicator 14.4.1 measures the proportion of fish stocks within biologically sustainable levels [45]. National ocean accounts can directly support reporting on this indicator by tracking the status of assessed fish stocks relative to MSY-based reference points. At global level, FAO estimates that the proportion of stocks fished within biologically sustainable levels declined from 90% in 1974 to 65.8% in 2017 [46].

¶11 For detailed guidance on integrating fish stock assessment with ocean accounts, see **TG-1.5 OA and Fisheries Management** and **TG-6.7 Fisheries Accounting: Integrating Stock Assessment**.

DRAFT

3.7.3 Water quality indicators

¶1 Water quality condition is fundamental to marine ecosystem function and is directly connected to land-based sources of pollution. Table 3.7.3 below summarises priority water quality variables for marine condition accounts.

Variable	Description
Nutrient concentrations	Dissolved nitrogen and phosphorus levels, which at elevated concentrations can cause eutrophication, algal blooms, and hypoxia [47] .
Dissolved oxygen	Oxygen levels in the water column, with low oxygen (hypoxia) indicating degraded condition and threat to marine life.
Chlorophyll concentration	A proxy for primary productivity and phytoplankton abundance, which at excessive levels may indicate eutrophication. Note that chlorophyll-a has context-dependent polarity (see the polarity reference table in Section 3.4.1) and the compiler must document the polarity assignment and its ecological rationale.
Ocean acidification	Sea water pH and carbonate saturation state, tracking the impacts of atmospheric CO2 absorption on marine chemistry.
Pollutant levels	Concentrations of heavy metals, persistent organic pollutants, plastics, and other contaminants.

¶2 The SDG framework includes indicator 14.1.1 (Index of coastal eutrophication and floating plastic debris density), which aggregates water quality and pollution variables into a composite measure [48] . National ocean accounts can provide the underlying data and support disaggregation of this aggregate indicator.

¶3 Links between water quality indicators and flows from the economy to the environment are addressed in **TG-3.4 Flows Economy to Environment**.

3.7.4 Integrated marine indicators

¶1 Several existing indicator frameworks integrate multiple dimensions of marine ecosystem condition:

¶2 **Essential Ocean Variables (EOVs)**: Defined by the Global Ocean Observing System (GOOS), EOVs provide a standardised set of variables spanning physics (temperature, salinity, currents), biogeochemistry (nutrients, oxygen, pH), and biology/ecosystems (phytoplankton, zooplankton, fish abundance, marine habitat) [49] . Alignment between ocean accounts and EOV frameworks enhances data interoperability.

¶3 **Ocean Health Index (OHI)**: The OHI assesses ocean health across ten goals reflecting the diverse benefits people derive from the ocean [50] . The OHI incorporates condition indicators for coral reefs, seagrass, mangroves, and other habitats within its “biodiversity” and “carbon storage” goals.

¶4 **Marine Biodiversity Observation Network (MBON) indicators**: MBON promotes standardised biodiversity observation. Its indicators of marine species diversity and community composition can inform the compositional state component of ecosystem condition accounts [51] .

¶5 **Taskforce on Nature-related Financial Disclosures (TNFD)**: The TNFD framework recommends disclosure of metrics on ecosystem condition relevant to business dependencies and impacts, including marine ecosystems [52] . Ocean accounts can provide standardised condition indicators suitable for corporate nature-related disclosure — see **TG-2.2 Macro-economic Dependencies** and **TG-1.7 OA and Multilateral Development Finance**.

3.7.5 Climate-related marine indicators

¶1 Climate-related indicators bridge the boundary between pressure indicators (measuring driving forces) and state indicators (measuring ecosystem response). Compilers are encouraged to include

DRAFT

climate-related variables within the relevant ECT classes of their condition accounts, rather than treating climate indicators as a separate category.

¶2 **Ocean warming indicators**: Sea surface temperature anomalies, marine heatwave frequency and intensity, and thermal stress accumulation (degree heating weeks) provide condition indicators for the physical state class of the ECT. These indicators are relevant across all marine ecosystem types and directly inform coral bleaching risk assessment and species distribution shifts.

¶3 **Ocean acidification indicators**: Sea water pH decline and aragonite saturation state track the chemical impacts of atmospheric CO2 absorption. These indicators are particularly consequential for calcifying organisms (corals, molluscs, and planktonic foraminifera) and can be incorporated into the chemical state class of condition accounts.

¶4 **Sea level indicators**: Relative sea level change affects coastal ecosystem extent directly, driving landward migration of intertidal ecosystems and inundation of low-lying habitats. Sea level indicators connect to both extent accounts (through ecosystem conversion) and condition accounts (through salinity and inundation stress).

¶5 **Extreme event indicators**: The frequency and severity of marine heatwaves, tropical cyclones, and hypoxic events can be recorded as condition-relevant pressures. Where these events cause measurable changes in ecosystem condition variables, they contribute to explaining temporal patterns in condition indicators.

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

DRAFT

5. References

1. ¶1 United Nations. (2021). *System of Environmental-Economic Accounting—Ecosystem Accounting*. Chapter 14, Figure 14.1. The information pyramid concept organises statistical products into a hierarchy from data and statistics through frameworks and accounts to indicators.
2. ¶2 SEEA EA, para 5.1.
3. ¶3 United Nations. (2021). *System of Environmental-Economic Accounting—Ecosystem Accounting*. Para 5.14, Table 5.1.
4. ¶4 SEEA EA, para 5.5-5.8. "The measurement of ecosystem condition in SEEA EA follows a three stage approach: (i) recording of values of ecosystem condition variables... (ii) deriving ecosystem condition indicators... (iii) aggregating indicators into ecosystem condition indices."
5. ¶5 SEEA EA, para 4.1-4.5. Ecosystem extent accounts record the area of ecosystem assets.
6. ¶6 SEEA EA, para 5.55-5.64. Condition indicators are derived from variables through normalisation.
7. ¶7 SEEA EA, Table 5.1. The SEEA Ecosystem Condition Typology organises characteristics into six classes.
8. ¶8 SEEA EA, para 5.79-5.87. Discussion of aggregation across indicators and ecosystem types.
9. ¶9 United Nations. (2025). *System of National Accounts 2025*. Figure 35.2. General ecosystem accounting framework showing relationships between environment, ecosystem assets, services, and society.
0. ¶10 SEEA EA, Table 5.2. Structure of ecosystem condition variable account.
1. ¶11 SEEA EA, Table 5.3. Structure of ecosystem condition indicator account.
2. ¶12 SEEA EA, Tables 5.4-5.6. Presentation of ecosystem condition indices.
3. ¶13 OECD. (2003). *Environmental Indicators: Development, Measurement and Use*. Reference paper.
4. ¶14 Global Ocean Observing System. (2019). Essential Ocean Variables. www.goosocean.org/eov (http://www.goosocean.org/eov); GEO BON. (2018). Essential Biodiversity Variables.
5. ¶15 SEEA EA, para 5.35-5.48. Discussion of reference conditions.
6. ¶16 SEEA EA, para 5.79-5.87. Section on ecosystem condition indices.
7. ¶17 SEEA EA, para 4.15-4.22. Recording ecosystem extent changes.
8. ¶18 SEEA EA, Table 4.1. Structure of ecosystem extent account.
9. ¶19 SEEA EA, para 4.23-4.28. Ecosystem type changes and conversion matrix.
0. ¶20 SEEA EA, para 4.23.
1. ¶21 SEEA EA, para 4.23-4.28; SEEA EA, Table 4.1.

2. ¶22 United Nations. (2017). *Global Indicator Framework for the Sustainable Development Goals*. A/RES/71/313. Indicator 14.5.1.
3. ¶23 Convention on Biological Diversity. (2022). *Kunming-Montreal Global Biodiversity Framework*. Target 3.
4. ¶24 UNCCD. (2017). SDG 15.3.1 Good Practice Guidance: Proportion of land that is degraded over total land area.
5. ¶25 SEEA EA, para 5.61. The formula for linear transformation of variables to indicators.
6. ¶26 SEEA EA, para 5.60. "For some condition variables, there is an inverse relationship between the value of the variable and the condition score."
7. ¶27 SEEA EA, Table A5.2.1. Assessment framework for selection of reference condition.
8. ¶28 SEEA EA, Table A5.2.2. Summary of methods for estimating possible reference condition for natural and managed ecosystems.
9. ¶29 SEEA EA, para 5.45.
0. ¶30 Pauly, D. (1995). Anecdotes and the shifting baseline syndrome of fisheries. *Trends in Ecology and Evolution*, 10(10), 430.
1. ¶31 United Nations. (2025). *System of National Accounts 2025*. Figure 35.3. Connections between ecosystem extent, condition, services (physical and monetary), and monetary asset accounts.
2. ¶32 Nardo, M., et al. (2005). *Handbook on constructing composite indicators: methodology and user guide*. OECD Statistics Working Papers 2005/03.
3. ¶33 SEEA EA, para 5.82. "Aggregation is possible across indicators within the same ECT class, across classes of characteristics in the ECT or across ecosystem types."
4. ¶34 SEEA EA, para 5.79.
5. ¶35 SEEA EA, para 5.83. "Aggregation can take the form of a condition index applied to each ecosystem type, weighted by the area of the ecosystem type."
6. ¶36 SEEA EA, para 5.80.
7. ¶37 SEEA EA, para 5.83.
8. ¶38 SEEA EA, para 5.79. "Where aggregation is undertaken, a clear link should be established to information on movements in individual indicators."
9. ¶39 Hughes, T.P., et al. (2017). Coral reefs in the Anthropocene. *Nature*, 546, 82-90.
0. ¶40 Reef Check Foundation. www.reefcheck.org (http://www.reefcheck.org). Standardised reef monitoring protocols.
1. ¶41 Ocean Health Index. (2023). Methods. www.oceanhealthindex.org (http://www.oceanhealthindex.org)
2. ¶42 SEEA EA, para 7.18-7.30. Fish stocks as non-cultivated biological resources in asset accounts.
3. ¶43 FAO. (2020). *The State of World Fisheries and Aquaculture 2020*. SDG 14.4.1 methodology.
4. ¶44 Pauly, D., et al. (1998). Fishing down marine food webs. *Science*, 279(5352), 860-863.
5. ¶45 United Nations. (2017). Global Indicator Framework. Indicator 14.4.1.
6. ¶46 FAO. (2020). SOFIA 2020. Global fish stock sustainability assessment.
7. ¶47 Diaz, R.J. & Rosenberg, R. (2008). Spreading dead zones and consequences for marine ecosystems. *Science*, 321(5891), 926-929.
8. ¶48 United Nations. (2017). Global Indicator Framework. Indicator 14.1.1.
9. ¶49 GOOS. (2019). *Essential Ocean Variables*. Global Ocean Observing System.
0. ¶50 Halpern, B.S., et al. (2012). An index to assess the health and benefits of the global ocean. *Nature*, 488, 615-620.
1. ¶51 Duffy, J.E., et al. (2013). Toward a coordinated global observing system for marine biodiversity. *Frontiers in Ecology and the Environment*, 11(7), 354-361.
2. ¶52 TNFD. (2023). *Recommendations of the Taskforce on Nature-related Financial Disclosures*. Appendix 2: Core global disclosure metrics.

DRAFT

Social and Livelihood Dependencies on Ocean Ecosystems

Provides guidance on compiling indicators of social and livelihood dependencies on ocean ecosystems, and on quantifying how populations rely on them.

Version 0.9.2 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

OUTCOME

This Circular provides guidance on compiling indicators of social and livelihood dependencies on ocean ecosystems, enabling practitioners to quantify how populations, households, and communities rely on marine and coastal natural capital for economic sustenance, food security, cultural identity, and wellbeing. The indicators are framed in poverty-alleviation terms, following the integrated ocean-poverty account approach of Burnside (2026), and are designed to feed disaster risk reduction processes under the Sendai Framework for Disaster Risk Reduction 2015-2030, where evidence on ocean-dependent populations is required for resilience planning, loss-and-damage assessment, and recovery prioritisation.

The indicators cover four dimensions: employment dependency, nutritional dependency, cultural dependency, and vulnerability (exposure, sensitivity and adaptive capacity of ocean-dependent populations). The guidance supports compilation of indicators aligned with SDG 1 (No Poverty), SDG 2 (Zero Hunger) — particularly Target 2.3, which explicitly references fishers among the small-scale food producers whose productivity and incomes should be doubled — SDG 5 (Gender Equality) through its treatment of women's roles in fisheries value chains, SDG 8 (Decent Work and Economic Growth), SDG 10 (Reduced Inequalities) through its attention to equity dimensions of ocean access, and SDG 14 (Life Below Water) — particularly Target 14.7 on increasing "the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources".

This Circular provides decision-relevant indicators for coastal poverty assessment, just transition planning, food security monitoring in fish-dependent populations, and the design of small-scale fisheries co-management arrangements. It connects the ecosystem service flows documented in TG-3.2 Flows from Environment to Economy to the social accounting approaches described in TG-3.5 Social Accounts, and so supplies the methodological bridge between biophysical ecosystem contributions and human wellbeing outcomes. It draws on the economic activity classifications established in TG-3.3 Economic Activity and complements TG-1.5 Fisheries Management by extending the analysis from resource extraction to the full social system of dependencies. For the foundational framework and standards overview, see TG-0.1 General Introduction and TG-0.2 Standards Overview.

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 4
3.1 Livelihood Dependency Framework 4
3.2 Employment Indicators 6
3.3 Food Security and Nutrition 9
3.4 Coastal Protection — Operationalising the SEEA-EA Coastal Protection Service 11
3.5 Cultural and Recreational Dependencies 12
3.6 Vulnerability Indicators 14
4. Compilation Considerations 16
4.1 Data sources 16
4.2 Compilation Procedure 19
4.3 Worked Example 26
4.4 Decision Use Cases 28
4.5 Spatial considerations 35
4.6 Temporal considerations 36
5. Acknowledgements 36
6. References 36
Footnotes 36

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Social and Livelihood Dependencies on Ocean Ecosystems (2026) (GOAP Technical Guidance on Ocean Accounting, TG-2.3, v0.9.2). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-2/2-3-livelihood-dependencies/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

1. Outcome

¶1 This Circular provides guidance on compiling indicators of social and livelihood dependencies on ocean ecosystems, enabling practitioners to quantify how populations, households, and communities rely on marine and coastal natural capital for economic sustenance, food security, cultural identity, and wellbeing [1]. The indicators are framed in poverty-alleviation terms, following the integrated ocean-poverty account approach of Burnside (2026) [2], and are designed to feed disaster risk reduction processes under the Sendai Framework for Disaster Risk Reduction 2015-2030 [3], where evidence on ocean-dependent populations is required for resilience planning, loss-and-damage assessment, and recovery prioritisation.

¶2 The indicators cover four dimensions: employment dependency, nutritional dependency, cultural dependency, and vulnerability (exposure, sensitivity and adaptive capacity of ocean-dependent populations). The guidance supports compilation of indicators aligned with SDG 1 (No Poverty), SDG 2 (Zero Hunger) — particularly Target 2.3, which explicitly references fishers among the small-scale food producers whose productivity and incomes should be doubled [4] — SDG 5 (Gender Equality) through its treatment of women's roles in fisheries value chains, SDG 8 (Decent Work and Economic Growth), SDG 10 (Reduced Inequalities) through its attention to equity dimensions of ocean access, and SDG 14 (Life Below Water) — particularly Target 14.7 on increasing "the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources" [5].

¶3 This Circular provides decision-relevant indicators for coastal poverty assessment, just transition planning, food security monitoring in fish-dependent populations, and the design of small-scale fisheries co-management arrangements. It connects the ecosystem service flows documented in **TG-3.2 Flows from Environment to Economy** to the social accounting approaches described in **TG-3.5 Social Accounts**, and so supplies the methodological bridge between biophysical ecosystem contributions and human wellbeing outcomes. It draws on the economic activity classifications established in **TG-3.3 Economic Activity** and complements **TG-1.5 Fisheries Management** by extending the analysis from resource extraction to the full social system of dependencies. For the foundational framework and standards overview, see **TG-0.1 General Introduction** and **TG-0.2 Standards Overview**.

DRAFT

2. Requirements

¶1 This Circular requires familiarity with:

- ¶2 **TG-0.1 General Introduction to Ocean Accounts** — for the conceptual framework connecting ecosystems to economic activity
- ¶3 **TG-0.2 Standards Overview** — for the international statistical standards underpinning ocean accounting, including SNA 2025, SEEA, and classification systems
- ¶4 **TG-3.3 Economic Activity Relevant to the Ocean** — for the ocean economy thematic and extended accounting framework, industry classifications (ISIC), and supply and use table methodology used to measure ocean economic activity
- ¶5 **TG-3.5 Social Accounts** — for the broader framework of social accounting including wellbeing, equity, and vulnerability dimensions

¶6 For guidance on measuring ecosystem service flows from ocean ecosystems to the economy, see **TG-3.2 Flows from Environment to Economy**. For documentation of traditional marine knowledge and customary practices, see **TG-3.6 Traditional Knowledge Accounts**. For detailed guidance on labour market measurement, including the concepts of compensation of employees and employment status, see the 2025 SNA Chapter 16 on Labour [6].

3. Guidance Material

¶1 Ocean ecosystems contribute to human livelihoods through multiple pathways: (1) employment in ocean-based industries, (2) provisioning of food and other marine products, (3) cultural, spiritual, and recreational benefits, and (4) the regulating services that protect coastal communities from hazards[7]. The SEEA Ecosystem Accounting framework describes these contributions as ecosystem services: "the contributions of ecosystems to the benefits that are used in economic and other human activity"[8]. This Circular provides guidance on measuring the human dependencies on these services, focusing on the social and livelihood dimensions that extend beyond purely economic measures.

¶2 Whilst **TG-3.5 Social Accounts** establishes the general framework for social accounting in the ocean context, this Circular applies that framework specifically to the measurement of livelihood dependencies. The distinct contribution of TG-2.3 is its focus on the dependency relationship itself: how populations, sectors, and communities rely on ocean ecosystems, and how changes in ecosystem condition translate into livelihood impacts. Where TG-3.5 asks "what is the social state?", this Circular asks "how dependent are communities on ocean ecosystems, and what happens if those ecosystems change?"

3.1 Livelihood Dependency Framework

¶1 A livelihood dependency framework organises the multiple ways in which individuals, households, and communities rely on ocean ecosystems for their economic, nutritional, cultural, and social sustenance. The framework distinguishes between direct and indirect dependencies, and between material and non-material dimensions of dependency[9]. The regulating-services pathway shown in Figure 2.3.1 (ocean ecosystems -> regulating services -> coastal protection) is operationalised in Section 3.4 using the SEEA-EA storm-mitigation service flow, rather than as a freestanding dependency indicator.

DRAFT

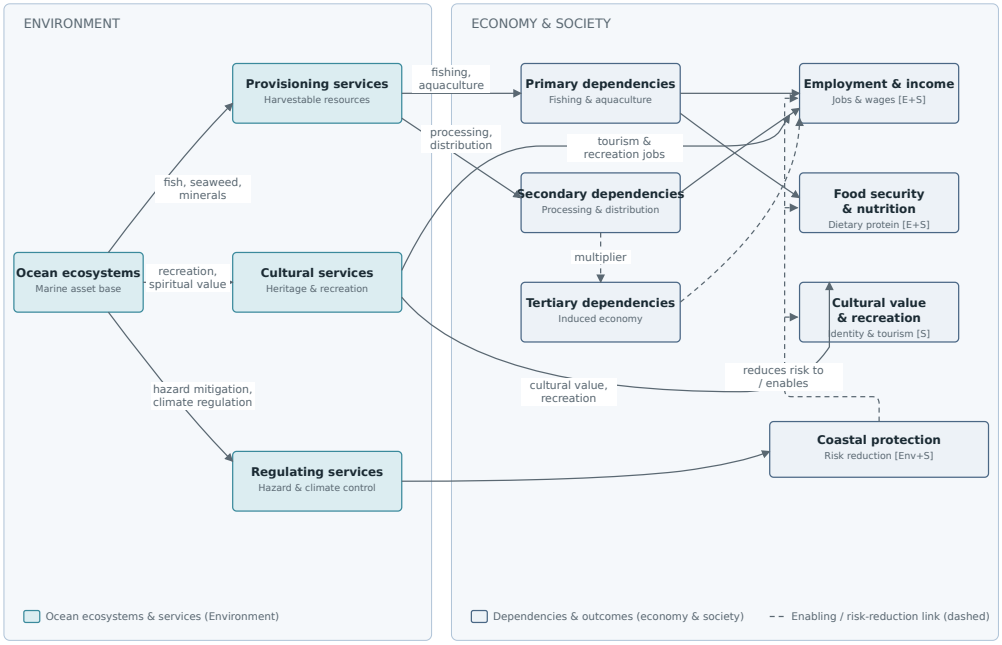


Figure 2.3.1 Ocean ecosystem services cascade into livelihood dependency tiers, employment, and enabling coastal protection. Dashed edges mark induced multipliers and enabling or risk-reduction links.

Source: TG-2.3 (livelihood dependency framework), Section 3 (indicator design).

Adapted from: SEEA EA 2024 ecosystem-services cascade, restructured for ocean livelihood applications.

DRAFT

3.1.1 Defining ocean-dependent livelihoods

¶1 Ocean-dependent livelihoods encompass all forms of work and subsistence activities that rely substantially on marine and coastal ecosystems. The 2025 SNA recognises that measuring wellbeing and sustainability requires extending measurement "beyond income and consumption to include…human capital as a produced asset"[10]. That extension covers the skills, knowledge, and capabilities that enable people to derive livelihoods from ocean resources. Human capital in the context of ocean-dependent livelihoods extends beyond formal education to the traditional ecological knowledge, navigation skills, and resource management capabilities that coastal communities develop through sustained engagement with marine environments.

¶2 Ocean-dependent livelihoods can be classified into three tiers. This classification parallels but does not replicate the SF-MST distinction between "direct effects" and "indirect and induced effects"[11]: whilst the SF-MST categories apply to economic impact measurement, the dependency tiers below describe the directness of the livelihood relationship to ocean ecosystems. Compilers should document which classification they adopt and how it maps to SF-MST or other frameworks used in their context.

¶3 **Primary dependencies:** Livelihoods directly engaged in harvesting marine resources or providing services within marine ecosystems. These include:

- ¶4 Commercial fishing (industrial, semi-industrial, and artisanal)
- ¶5 Subsistence fishing and gleaning
- ¶6 Aquaculture and mariculture operations
- ¶7 Seaweed and shellfish harvesting
- ¶8 Marine tourism operations (diving, snorkelling, whale watching, sport fishing)

¶9 **Secondary dependencies:** Livelihoods in sectors that process, distribute, or add value to marine resources:

- ¶10 Seafood processing and packaging
- ¶11 Fish marketing and distribution
- ¶12 Boat building and repair
- ¶13 Fishing gear manufacture and supply
- ¶14 Tourism accommodation and services in coastal areas

¶15 **Tertiary dependencies:** Livelihoods supported by the multiplier effects of ocean-based economic activity:

- ¶16 Retail and hospitality in fishing communities
- ¶17 Transport services for coastal trade
- ¶18 Financial and professional services to ocean industries
- ¶19 Public administration related to marine management

¶20 These tiers correspond to the ocean economy industry classifications detailed in **TG-3.3 Economic Activity**, which provides the ISIC-based framework for identifying and measuring ocean-dependent, ocean-related, and partially ocean-related industries.

3.1.2 Dependency indicators

¶1 Dependency indicators quantify the extent to which populations, sectors, or regions rely on ocean ecosystems. Key indicator categories include:

¶2 **Employment dependency indicators:**

- ¶3 Share of employment in ocean-dependent sectors (percent of total employment)
- ¶4 Number of persons employed in fishing, aquaculture, and marine tourism
- ¶5 Share of household income derived from ocean-dependent activities
- ¶6 Employment concentration ratio (ocean employment in coastal areas relative to national average)

¶7 **Nutritional dependency indicators:**

- ¶8 Share of dietary protein from marine sources
- ¶9 Per capita fish consumption (kg per year)
- ¶10 Share of households relying on subsistence fishing for food security
- ¶11 Value of subsistence marine harvests relative to household consumption

¶12 **Economic dependency indicators:**

- ¶13 Ocean sector value added as share of GDP (see **TG-2.5 Ocean Economy Structure**)
- ¶14 Export earnings from marine products as share of total exports
- ¶15 Share of government revenue from marine resource access fees and licenses

¶16 **Cultural dependency indicators:**

- ¶17 Number of communities with traditional marine tenure systems
- ¶18 Participation rates in traditional fishing practices
- ¶19 Cultural sites of marine significance per coastal area
- ¶20 Intergenerational transmission of marine knowledge and skills

¶21 Recording the flows of ecosystem services to human users supports understanding of livelihood dependencies, and extends the logic of SEEA EA para. 2.31 on intermediate service flows [12].

3.2 Employment Indicators

DRAFT

¶1 Whilst **TG-3.5 Social Accounts** covers general ocean sector employment measurement, this section focuses specifically on compiling employment as a dependency indicator. The measure of interest is how reliant communities and populations are on ocean-based employment, which a headcount of jobs alone does not capture[13].

3.2.1 Direct employment

¶1 Direct employment encompasses all persons engaged in activities that harvest marine resources or operate within marine spaces. SDG indicator 14.7.1 measures "Sustainable fisheries as a proportion of GDP in small island developing States, least developed countries and all countries"[14], whilst employment measures provide the complementary livelihood dimension.

¶2 Key direct employment categories for ocean accounting include:

¶3 **Fisheries employment:**

- ¶4 Commercial fishing vessel crews (by vessel size category)
- ¶5 Artisanal and small-scale fishers
- ¶6 Subsistence fishers (including those not fully captured in formal employment statistics)
- ¶7 Aquaculture workers (marine and brackish water operations)

¶8 SDG Target 2.3 calls for doubling "the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers"[15]. Employment accounts should distinguish small-scale fisheries from industrial operations to support monitoring of this target.

¶9 The SEEA for Agriculture, Forestry and Fisheries (SEEA AFF) provides an integrated framework describing how "biophysical and management information relevant to agriculture, forestry and fisheries production can be integrated into the statistical framework"[16]. For guidance on integrating fisheries stock assessment data with employment accounts, see **TG-1.5 Fisheries Management**.

¶10 **Marine tourism employment:** SDG Target 8.9 calls for implementing "policies to promote sustainable tourism that creates jobs"[17]. Marine tourism employment includes:

- ¶11 Tour operators for marine activities (diving, snorkelling, boat tours)
- ¶12 Recreational fishing guides and charter operators
- ¶13 Beach and coastal recreation facility staff
- ¶14 Marine wildlife watching operators
- ¶15 Coastal accommodation workers directly serving marine tourists

¶16 Marine tourism employment is commonly seasonal and precarious, with a small core of permanent staff complemented by temporary and on-call workers[18]. This pattern affects vulnerability assessments.

¶17 **Other direct ocean employment:**

- ¶18 Offshore energy sector employees
- ¶19 Port and harbour workers
- ¶20 Coastal construction and maintenance workers
- ¶21 Marine research and conservation workers

¶22 **Classification note — "ocean-operating" versus "ocean-dependent" employment:** Maritime transport workers (ISIC 50) use the ocean as their operating environment but do not depend on ocean ecosystem services in the same way as fishers or aquaculture workers. Accordingly, ISIC 50 is assigned to the secondary tier rather than direct employment. Within ISIC 50, compilers should distinguish two subcategories where 4-digit data are available: inter-island ferry and coastal passenger services (ISIC 50.10) are classified as "high ocean-operating intensity" within the secondary tier. Deep-sea cargo shipping (ISIC 50.20) is classified as "low ocean-ecosystem dependency" within the same tier. These subcategories should be reported separately in secondary em-

DRAFT

ployment tables to enable analysts to identify the sub-population with stronger livelihood dependency on ocean conditions. This classification follows the principle that tier assignment is determined by economic activity type and dependency on ocean ecosystem services, not physical proximity to the ocean. That principle preserves comparability with **TG-3.3 Economic Activity** classification.

3.2.2 Indirect employment

¶1 Indirect employment arises in sectors that supply goods and services to ocean-dependent industries. The SF-MST describes these as activities "in the supply chain of tourism characteristic products"[19]. For ocean accounting, the analogous concept encompasses supply chains for fishing, aquaculture, marine tourism, and other ocean sectors.

¶2 Measuring indirect employment requires either:

- ¶3 Input-output analysis to trace supply chain linkages
- ¶4 Establishment surveys that identify suppliers to ocean industries
- ¶5 Employment estimates based on intermediate consumption patterns

¶6 For practical compilation, countries may focus on the supply chain sectors with known connections to ocean industries[20].

¶7 Key indirect employment categories include:

- ¶8 Maritime transport workers (ISIC 50; subcategory classification: Section 3.2.1)
- ¶9 Fishing equipment and gear manufacture
- ¶10 Boat building and repair services
- ¶11 Seafood processing and packaging
- ¶12 Cold chain and transport logistics
- ¶13 Marine fuel and supplies provision
- ¶14 Professional and financial services to ocean industries

3.2.3 Induced employment

¶1 Induced employment results from the spending of wages earned in ocean-dependent sectors. Induced effects are typically estimated using economic multipliers derived from input-output models[21]. For ocean dependency indicators, induced employment estimates can illustrate the broader economic significance of ocean-based livelihoods but should be presented separately from direct and indirect measures.

¶2 Table 1 summarises the data requirements and methodological approaches for compiling employment dependency indicators across the three tiers.

Tier	Scope	Primary Data Sources	Estimation Method	Key Challenges
Direct	Persons harvesting marine resources or operating in marine spaces	Labour force surveys, fisheries registries, vessel crew records	Direct count from administrative/survey data	Informal employment, subsistence fishers underreported
Indirect	Supply chain employment serving ocean industries (including ISIC 50 maritime transport)	Establishment surveys, input-output tables	Supply chain tracing via I-O analysis or surveys	Boundary definition, partial attribution

DRAFT

Tier	Scope	Primary Data Sources	Estimation Method	Key Challenges
Induced	Employment from spending of ocean sector wages	Household expenditure surveys, I-O multipliers	Multiplier-based estimation from I-O models	Multiplier uncertainty, double-counting risk

¶3 *Table 1: Employment dependency indicator data requirements by tier*

3.2.4 Employment characteristics

¶1 Beyond counting employment, ocean accounts should characterise employment quality using the decent work framework dimensions described in **TG-3.5 Social Accounts**. The 2025 SNA provides detailed guidance on labour market measurement, including employment status, compensation of employees, and the distinction between formal and informal employment [22]. Key characteristics include:

Characteristic	Relevance to Ocean Employment
Sex	Women play significant but often under-recognised roles in fish processing and gleaning
Age	Many fisheries face aging workforce issues; youth employment in marine tourism
Employment status	High rates of self-employment in small-scale fisheries
Full-time/part-time	Seasonal variation particularly in tourism and some fisheries
Formal/informal	High informality rates in small-scale fisheries and coastal tourism
Geographic location	Concentration in coastal communities affects spatial development patterns

¶2 *Table 2: Employment characteristics relevant to ocean dependency analysis*

¶3 Such disaggregation reveals patterns that aggregate counts obscure: the high proportion of informal employment in small-scale fisheries, or the seasonal concentration of marine tourism employment [23].

DRAFT

3.3 Food Security and Nutrition

¶1 This section addresses the dependency dimension of marine food provisioning. For the ecosystem service flow perspective, see **TG-3.2 Flows from Environment to Economy**, Section 3.1 on provisioning services.

3.3.1 Protein dependency

¶1 Fish and other aquatic foods are a primary source of animal protein, with particularly high consumption in coastal regions, Small Island Developing States, and countries with extensive traditional fishing cultures [24], [25]. SDG Target 2.1 calls for ending hunger and ensuring "access by all people…to safe, nutritious and sufficient food all year round" [26].

¶2 Key protein dependency indicators include:

¶3 **Per capita consumption:**

- ¶4 Fish consumption in kilograms per person per year
- ¶5 Share of animal protein from aquatic sources
- ¶6 Trend in fish consumption over time

¶7 **Population-level dependencies:**

- ¶8 Number of persons deriving 20% or more of animal protein from fish
- ¶9 Number of persons in fish-dependent communities (where fish provides majority of animal protein)

- ¶10 Geographic distribution of protein dependency (coastal vs inland populations)

¶11 **Nutritional quality:**

- ¶12 Contribution of fish to essential micronutrient intake (omega-3 fatty acids, vitamin D, iodine, zinc)
- ¶13 Role of small fish in addressing hidden hunger (micronutrient deficiencies)

¶14 Nutritional dependency indicators measure the human welfare dimension of the biomass provisioning services described in SEEA EA Table 6.3 [27].

3.3.2 Subsistence harvesting

¶1 Beyond commercial fisheries, subsistence harvesting provides essential food for coastal and island communities, often without being captured in formal economic statistics. Subsistence fishing includes:

- ¶2 Small-scale artisanal fishing for household consumption
- ¶3 Gleaning of shellfish, seaweed, and other intertidal resources
- ¶4 Reef fishing and spearfishing in traditional territories
- ¶5 Harvesting of sea cucumbers, sea urchins, and other marine invertebrates

¶6 For subsistence harvesting, the ecosystem service flows directly to households without entering market transactions [28]. This treatment is consistent with the ecosystem service flow accounting in **TG-3.2 Flows from Environment to Economy** and with the artisanal fisheries coverage in **TG-1.5 Fisheries Management**. SDG Target 14.b emphasises the importance of providing "access for small-scale artisanal fishers to marine resources and markets" [29].

¶7 Measuring subsistence dependencies requires:

- ¶8 Household surveys capturing marine harvesting activities
- ¶9 Participatory assessments with coastal communities
- ¶10 Time-use surveys documenting harvesting activity
- ¶11 Estimation of physical quantities harvested for own consumption

¶12 The monetary value of subsistence harvests can be imputed using local market prices for equivalent products. The 2025 SNA provides guidance on valuing own-account production for inclusion in household income and consumption measures [30].

3.3.3 Food security vulnerability

¶1 Food security encompasses four dimensions: availability, access, utilisation, and stability [31]. Table 3.3.3 below summarises how ocean ecosystem dependencies affect each dimension.

Dimension	Description
Availability	Marine ecosystems supply fish and other aquatic foods. Changes in ecosystem condition (overfishing, habitat loss, climate impacts) directly affect food availability.
Access	Poverty, market structure, and governance arrangements determine which populations can access marine foods. Equity in access is addressed in **TG-3.5 Social Accounts**.
Utilisation	Safe food handling, nutritional knowledge, and cooking practices affect how marine foods contribute to nutrition.
Stability	Seasonal variation in fish availability, stock fluctuations, and climate variability affect the reliability of marine food supplies.

¶2 Indicators of food security vulnerability related to ocean ecosystems include:

- ¶3 Share of households reporting inadequate fish availability
- ¶4 Price volatility of marine food products

DRAFT

- ¶5 Seasonal patterns in fish consumption
- ¶6 Alternative protein source availability for fish-dependent communities

3.4 Coastal Protection — Operationalising the SEEA-EA Coastal Protection Service

¶1 Coastal ecosystems (coral reefs, mangroves, saltmarshes, seagrass meadows, oyster reefs, and coastal dunes) attenuate waves, dissipate storm surge, and stabilise shorelines. Communities behind these features depend on the regulating services they supply for physical protection of dwellings, infrastructure, and lives. The "regulating services -> coastal protection" arm in Figure 2.3.1 is operationalised here.

¶2 The 2019 discussion paper on coastal protection dependency indicators (Crossman, Nedkov, Brander) has been superseded by the adopted SEEA Ecosystem Accounting standard (UN et al., 2021; current consolidated edition December 2024). The standard does not specify dependency indicators in the original proposed form and deliberately does not endorse specific datasets or platforms. SEEA-EA Table 6.3 splits the previously combined "water flow regulation for mitigating river and coastal flooding" service into three separate reference services: **Water flow regulation**, **Flood control**, and **Storm mitigation** [32].

¶3 **Which of the three applies here.** Coastal protection is a sub-service of **Flood control services**, defined in Table 6.3 as "ecosystem contributions of linear elements in the seascape (e.g. coral reefs, sand banks, dunes or mangrove ecosystems along the shore) to protecting the shore and thus mitigating the impacts of tidal surges or storms on local communities". **Storm mitigation services** are a different reference service, covering "the impacts of windstorms, sandstorms and other types of storms (*other than water-related events*)". Wave attenuation and storm surge dissipation are water-related events, so this Circular's subject is the coastal protection service under flood control. Compilers should record it there, not against storm mitigation, or national entries will not reconcile with Table 6.3 or with cross-country comparisons keyed to it. The two indicators originally considered for a dedicated coastal-protection dependency sub-section (population exposure in the absence of natural coastal protection, and the value of avoided damage) are absorbed into standard service-flow accounting rather than treated as freestanding dependency metrics:

- ¶4 **Population exposure in the absence of natural coastal protection** is the counterfactual baseline for the coastal protection service flow. It is captured in the **service benefiting area (SBA)** dimension of the Chapter 7 physical supply-and-use table, with the **service providing area (SPA)** being the ecosystem asset that supplies the protection (SEEA-EA §7.66).
- ¶5 **Value of avoided damage** is the monetary valuation method covered in SEEA-EA Chapter 9, in particular §9.3.6 (expected expenditure / avoided-damage methods) and §9.4 (service-specific valuation guidance) [33].

¶6 Chapter 14 of the SEEA-EA (Tables 14.3–14.4) lists indicator categories but no named indicators of this kind. Reference-list and capacity concepts sit in Chapter 6 §6.5 and Appendix A6.1.

3.4.1 Where the account entry is specified

¶1 The coastal protection service entry in the Chapter 7 physical supply and use table — the service providing area, the service benefiting area, and the physical and monetary service flows — is specified in **TG-3.2 Flows from Environment to Economy** Section 3.3, and the data sources and hydrodynamic models that populate the counterfactual are in **TG-4.1 Remote Sensing and Geospatial Data** Section 3.2.6. Neither is restated here.

¶2 What this Circular adds is the dependency reading of those entries: how many people the service protects, how much of their exposure it removes, and what happens to that dependency when the SPA degrades. The indicators below take the compiled service flow as their input.

3.4.3 Anchor worked examples

¶1 Three published national-scale applications are recommended as templates:

- ¶2 **World Bank WAVES (Beck & Lange 2016)** — "Managing Coasts with Natural Solutions: Guidelines for Measuring and Valuing the Coastal Protection Services of Mangroves and Coral Reefs." Sets the methodological frame for SEEA-compatible coastal protection accounts.
- ¶3 **Menéndez et al. (2018)** — national-scale Philippines mangrove storm-protection account, demonstrating the SBA / avoided-damage approach at country scale.
- ¶4 **ABS National Ecosystem Accounts — coastal protection account** — the Australian Bureau of Statistics published a coastal protection account quantifying dwellings and residents protected by mangroves and saltmarsh, populating the SEEA-EA storm-mitigation cell in a national accounting context.

3.4.4 Illustrative composite where SBA data are unavailable

¶1 Where the SBA-based service-flow approach cannot yet be populated (typically because elevation, population, or hydrodynamic modelling capacity are unavailable), compilers may report an **illustrative composite dependency index** drawing on the Arkema et al. (2013) approach as an interim measure. The composite is calculated as:

```
Coastal protection dependence = m × (n × (1 − o × p × q)) / 2
```

¶2 where:

- ¶3 **m — Magnitude of benefit (dependence):** the proportion of the national population that benefits from coral reefs and mangroves in reducing exposure to storms and sea-level rise (Arkema et al., 2013).
- ¶4 **n — Exposure (LECZ population):** the proportion of the population in the Low Elevation Coastal Zone, i.e. those exposed to storms and sea-level rise (McGranahan et al., 2007).
- ¶5 **o, p, q — Substitutability:** GDP per capita (o), governance quality (p), and density of impervious surfaces (q), capturing the population's ability to substitute natural protection with built defences, institutional capacity, and infrastructure (Adger et al., 2005; Brooks et al., 2005; Tol et al., 2004).

¶6 The `(1 − o × p × q)` term lowers the composite where substitutes are strong. o, p and q are proxies for the population's capacity to replace lost protection or adapt to its loss. That is adaptive capacity, a component of vulnerability (see the livelihood vulnerability index, Section 4.2, Step 3), not of dependence: the service-flow approach in §3.4.1 records the protection a population receives whether or not it could replace it. The composite therefore mixes dependence (m) with exposure (n) and adaptive capacity (o, p, q). Compilers using it should report m, n and the substitutability term (o × p × q) alongside the composite, and should not combine the composite with the livelihood vulnerability index, which would count exposure and adaptive capacity twice. **The illustrative composite is not a substitute for the SPA/SBA service-flow approach in §3.4.1.** Compilers using it should clearly flag the indicator as a transitional measure and document a plan to migrate to SEEA-EA service-flow accounting as elevation, population, and hydrodynamic inputs become available.

3.5 Cultural and Recreational Dependencies

¶1 Ocean ecosystems support non-material dimensions of human wellbeing through cultural connections, recreational opportunities, and spiritual significance. The SEEA EA describes cultural services as "experiential and intangible services related to the perceived or actual qualities of ecosystems whose existence and functioning contribute to a range of cultural benefits" [34] . Whilst **TG-3.2 Flows from Environment to Economy** documents the ecosystem service flows themselves

DRAFT

(Section 3.1.3 on cultural services), this section addresses the human dependency dimension — how communities and populations rely on these cultural services for their wellbeing and identity.

3.5.1 Cultural ecosystem services

¶1 Marine cultural services encompass:

¶2 **Recreation-related services:** The ecosystem contributions to recreational activities including swimming, diving, snorkelling, surfing, recreational fishing, and wildlife watching [35]. These are considered final ecosystem services since they are directly enjoyed by people [36].

¶3 Indicators of recreational dependency include:

- ¶4 Visitor days to marine recreation areas
- ¶5 Participation rates in marine recreational activities
- ¶6 Economic expenditure on marine recreation
- ¶7 Accessibility of marine recreation opportunities across population groups

¶8 **Visual amenity services:** The contribution of marine seascapes to aesthetic enjoyment and property values [37].

¶9 **Education and research services:** The contribution of marine ecosystems to scientific research, environmental education, and the generation of knowledge [38].

¶10 **Spiritual, artistic, and symbolic services:** The contributions to cultural identity, spiritual practices, and artistic inspiration [39]. For many coastal and island cultures, the ocean holds profound spiritual significance that cannot be adequately captured through quantitative indicators.

3.5.2 Cultural identity and traditional practices

¶1 For Indigenous Peoples and traditional coastal communities, cultural dependencies on ocean ecosystems may be the deepest dimension of human-ocean relationships. The TNFD notes that "Indigenous Peoples and Local Communities manage or have tenure over" significant proportions of remaining intact natural areas [40], with analogous relationships existing for traditional marine territories.

¶2 Cultural identity dependencies include:

- ¶3 Traditional fishing practices and their role in cultural transmission
- ¶4 Ceremonial and ritual uses of marine resources
- ¶5 Oral traditions and stories related to the ocean
- ¶6 Place-based identity connected to specific marine areas
- ¶7 Traditional governance systems for marine resources (see **TG-3.6 Traditional Knowledge Accounts**)

¶8 Measuring cultural dependencies requires participatory and qualitative approaches, as described in **TG-3.5 Social Accounts** and **TG-3.6 Traditional Knowledge Accounts**. Both circulars emphasise the need for community-led methods that respect Indigenous data sovereignty. Quantitative proxies may include:

- ¶9 Number of communities with active traditional marine tenure systems
- ¶10 Participation rates in traditional fishing practices by age group
- ¶11 Documentation of marine cultural heritage sites
- ¶12 Rates of intergenerational transmission of marine knowledge

3.5.3 Tourism and recreation economies

¶1 SDG Target 14.7 calls for increasing "the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism" [41].

DRAFT

¶2 Tourism dependency indicators connect to the broader ocean economy measurement described in **TG-2.5 Ocean Economy Structure**:

- ¶3 Tourism GDP attributable to marine attractions
- ¶4 Employment in marine tourism relative to total tourism employment
- ¶5 International visitor arrivals motivated by marine experiences
- ¶6 Revenue from marine protected area visitation

¶7 The SF-MST provides the statistical framework for linking ecosystem accounting to measures of tourism activity[42], enabling integration of cultural ecosystem service flows with tourism economic accounts.

3.6 Vulnerability Indicators

¶1 **TG-3.5 Social Accounts** provides the general vulnerability and resilience framework for ocean social accounts. This section applies that framework specifically to livelihood dependencies, focusing on how to measure the vulnerability that arises from reliance on ocean ecosystems. Vulnerability encompasses sensitivity or susceptibility to harm and lack of capacity to cope and adapt[43].

3.6.1 Exposure to ocean-related risks

¶1 Ocean-dependent communities face multiple risks:

¶2 **Ecological risks:** Overfishing, habitat degradation, pollution, and invasive species can reduce the productivity of marine ecosystems and the services they provide. The SEEA EA describes ecosystem condition indicators that track these changes (see **TG-2.1 Biophysical Indicators**).

¶3 **Climate risks:** Ocean warming, acidification, sea level rise, and changing storm patterns directly affect marine ecosystems and coastal communities. SDG Target 14.2 calls for managing marine ecosystems "including by strengthening their resilience"[44]. SDG Target 1.5 calls for building "the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events"[45].

¶4 **Economic risks:** Volatile commodity prices, changing trade policies, and market disruptions can undermine the economic viability of ocean-dependent livelihoods.

¶5 **Governance risks:** Weak or inequitable governance arrangements may fail to protect community access rights or ensure sustainable management.

¶6 The following indicators measure exposure across these risk categories:

- ¶7 Share of coastal population in areas exposed to sea level rise or storm surge
- ¶8 Dependence on fish stocks assessed as overfished or uncertain
- ¶9 Share of employment in sectors exposed to climate-sensitive marine conditions
- ¶10 Concentration of livelihoods in single marine resources or activities

3.6.2 Sensitivity indicators

¶1 Sensitivity measures how significantly populations would be affected by changes in ocean ecosystems or disruptions to ocean-based activities:

¶2 **Economic sensitivity:**

- ¶3 Share of household income from ocean-dependent sources
- ¶4 Availability of alternative livelihood options
- ¶5 Asset base and savings to buffer income losses
- ¶6 Access to credit and insurance

¶7 **Nutritional sensitivity:**

- ¶8 Share of dietary protein from marine sources

DRAFT

- ¶9 Availability and affordability of alternative protein sources
- ¶10 Nutritional status (particularly in children and pregnant women)

¶11 **Social sensitivity:**

- ¶12 Poverty rates in ocean-dependent communities
- ¶13 Age structure of workforce (older workers less adaptable)
- ¶14 Social marginalization affecting access to support
- ¶15 Housing and infrastructure quality in coastal settlements

3.6.3 Adaptive capacity indicators

¶1 **Human capital:**

- ¶2 Educational attainment in coastal communities
- ¶3 Occupational skills transferable to other sectors
- ¶4 Health status affecting work capacity

¶5 **Social capital:**

- ¶6 Strength of community organisations and networks
- ¶7 Collective action capacity for resource management
- ¶8 Access to information and decision-making processes

¶9 **Financial capital:**

- ¶10 Access to savings and financial services
- ¶11 Insurance coverage for weather and market risks
- ¶12 Access to credit for livelihood diversification

¶13 **Institutional capital:**

- ¶14 Social protection coverage measured by SDG indicator 1.3.1 ("Proportion of population covered by social protection floors/systems")[46]. SDG 1.3.1 measures institutional reach of social protection systems and is distinct from the poverty headcount ratio (SDG 1.1.1 / 1.2.1), which measures the prevalence of poverty. Both are relevant to ocean-dependent populations but answer different questions: social protection coverage indicates the capacity of formal systems to buffer shocks, whilst the poverty headcount indicates the magnitude of pre-existing deprivation. Compilers should report the two indicators separately rather than collapsing them into a single dependency or vulnerability score.
- ¶15 Governance capacity for adaptive management (see **TG-3.7 Governance Accounts**)
- ¶16 Policy support for livelihood transitions

¶17 Understanding the specific ecosystem services on which livelihoods depend, and the current and projected condition of those services, enables targeted vulnerability assessment[47].

3.6.4 Livelihood vulnerability indicator summary

¶1 Table 3 provides a summary of livelihood vulnerability indicators organised by the exposure-sensitivity-adaptive capacity framework. Each indicator is linked to the account type within the Ocean Accounts framework that supplies the relevant data.

Vulnerability Component	Indicator	Data Source	Account Link
Exposure	Storm frequency/intensity	Climate data	Governance accounts
Exposure	Fish stock variability	Stock assessments	Asset accounts
Sensitivity	% income from ocean	Household surveys	Economic accounts
Sensitivity	Dietary fish dependence	Consumption surveys	Social accounts
Adaptive capacity	Skill diversity	Labour surveys	Social accounts

DRAFT

Vulnerability Component	Indicator	Data Source	Account Link
Adaptive capacity	Asset ownership	Household surveys	Economic accounts

¶2 *Table 3: Livelihood vulnerability indicators by component*

3.6.5 Composite vulnerability indices

¶1 Vulnerability indicators across exposure, sensitivity, and adaptive capacity dimensions can be combined into composite vulnerability indices that identify priority populations or areas for policy attention. Because a composite index aggregates components whose relative importance is contestable, its credibility rests on a single condition: that every methodological choice is transparent and revisable. A defensible index therefore (1) uses a transparent and replicable methodology, (2) weights its components against local context and priorities, (3) documents the theoretical framework underpinning the choice of components and weights, (4) is validated through community consultation, and (5) is updated as conditions change.

¶2 For guidance on integrated indicator frameworks and quality assurance of composite indices, see **TG-0.7 Quality Assurance**.

4. Compilation Considerations

4.1 Data sources

¶1 Social and livelihood dependency indicators draw on diverse data sources:

¶2 **Household surveys:** Labour force surveys provide employment data, living standards surveys capture consumption and income patterns, and specialised coastal community surveys can provide targeted dependency information.

¶3 **Administrative records:** Fishing licenses, vessel registrations, marine worker registrations, and tourism statistics provide administrative data on ocean sector participation.

¶4 **Fisheries data:** Catch statistics, vessel monitoring data, and stock assessments provide physical measures of resource extraction that can be linked to employment and livelihood data.

¶5 **Participatory assessments:** Community consultations and participatory mapping document dependencies not captured in formal statistics, particularly for subsistence activities and cultural dimensions.

¶6 For detailed guidance on data sources and collection methods, see **TG-4.2 Survey Methods** and **TG-4.3 Administrative Data**.

4.1.1 Community sense-checking of data sources

¶1 Secondary data sources alone are not sufficient to determine which dependencies are captured in the account and which are systematically obscured. Before compilation begins, compilers should undertake a structured sense-check with communities in the spatial units covered by the account. The purpose is not validation of results (which occurs at the compilation stage; Section 4.2), but verification of whether the source list and its assumed coverage match community experience.

¶2 The minimum standard is one structured engagement per spatial unit, disaggregated to include separate sessions or sub-groups for women, youth, elders, and persons with disabilities. Mixed sessions alone do not meet the standard, because the dependency categories most likely to be missed by official sources (e.g. gleaning, shore-based processing, subsistence harvesting by women and children, ceremonial use) are precisely those that mixed sessions are least likely to surface. Where capacity permits, additional disaggregation by livelihood type, migration status, or Indigenous identity is appropriate. The methodological approach is consistent with that established in the

DRAFT

GOAP Social Accounts methodology[48], which treats disaggregated consultation as a quality assurance requirement rather than a procedural courtesy.

¶3 Three questions structure the sense-check at the source stage:

¶4 **(1) Coverage.** Does each proposed secondary source list or count the people who actually undertake ocean-dependent activities in this place? Findings on systematic undercounts feed directly into the adjustment factors applied in Section 4.2 (in particular Step 1 sub-step 2 on informal and subsistence employment, and Step 3 sub-step 3 on sensitivity indicators).

¶5 **(2) Legitimacy of additional sources.** Are there community-held data sources — community monitoring programmes, women's cooperative records, traditional catch records, locally maintained registers — that should be incorporated alongside official sources? The conditions under which traditional and Indigenous knowledge holdings can enter the account are governed by **TG-3.6 Traditional Knowledge Accounts**, including Free, Prior and Informed Consent and the principle that the decision to share rests with knowledge holders.

¶6 **(3) Disaggregation that matters.** At what spatial and demographic level does the data need to be disaggregated for the policy question to be answerable? Communities can identify when district-level aggregation obscures settlement-level vulnerability, or when household-head reporting misses the labour of other household members. These findings shape the spatial unit chosen in Section 4.2 Step 3 sub-step 1.

¶7 Each engagement should be documented with the date, the groups consulted, the questions asked, and the findings — particularly any source-coverage gaps that will require adjustment or qualitative annotation downstream. This documentation forms part of the metadata required under Section 4.2 Step 5. For detailed survey and consultation protocols, see **TG-4.2 Survey Methods** and **TG-4.3 Administrative Data**.

4.1.2 Integration with existing survey systems

¶1 The dependency indicators in this Circular are designed as an analytical overlay on existing national household survey systems, not as a new statistical operation. Most of the variables needed are already collected by national statistical offices for other purposes. The compiler's task is principally one of recoding, cross-tabulation, and concordance, supplemented by a small number of genuinely new variables. Reframing the work in this way — as integration rather than new collection — is essential to keeping it tractable for NSOs already operating at capacity, and is consistent with the integrated ocean-poverty account framework set out by Burnside (2026)[2].

¶2 The principal survey instruments and their roles are:

- ¶3 **Household Income and Expenditure Surveys (HIES) / Living Standards Measurement Studies (LSMS):** Provide the household-level income, consumption, asset, and dwelling-quality variables required for sensitivity and adaptive-capacity components of the livelihood vulnerability index, and the fish-consumption variables required for the fish protein dependency ratio. HIES also already populates the SDG 1.3.1 social protection coverage indicator referenced in Section 3.6.3. The HIES is the anchor source for the vulnerability index (see Section 4.2 Step 5 on reference-year metadata).
- ¶4 **Labour Force Surveys (LFS):** Provide the industry-by-employment cross-tabulations required for the ocean employment dependency ratio, and the disaggregation by sex, age, formal/informal status, and occupation required for sub-step 2a. The LFS already populates SDG indicators 8.3.1 (informal employment) and 8.5.2 (unemployment), and the relevant variables for occupational diversity required in the adaptive capacity component.
- ¶5 **Population and Housing Censuses:** Provide the small-area population denominators required for spatial disaggregation. They do not serve as anchor sources for dependency indicators because the inter-censal interval is too long.

DRAFT

- ¶6 **Agricultural and fisheries censuses or registers; tourism satellite accounts:** Supply industry-side production, capture, and value-added data used to validate household-side reports and to apportion ocean shares within mixed industries.

¶7 The genuinely new variables for which existing survey instruments typically do not provide coverage — and which therefore require either supplementary modules, dedicated coastal community surveys, or community sense-check engagement (Section 4.1.1) — are limited and identifiable. The principal ones are:

- ¶8 Physical quantities of subsistence marine harvests (including gleaning, shore-based collection, and ceremonial use), in volume or weight terms, for household consumption.
- ¶9 Shannon diversity index of household livelihoods across industries (computable from existing labour-force module data with a small recoding step, but not currently reported in any standard tabulation).
- ¶10 Cultural dependency variables (Section 3.5) where these are not already documented by traditional-knowledge registers.

¶11 The integration approach has two consequences that compilers should make explicit in publication metadata. First, the indicators are an 'analytical layer' on existing official statistics — not a separate accounting operation — and so are bound by the reference-year, vintage, and revision conventions of their underlying sources (see Section 4.2 Step 5). Second, the dependency indicators are framed throughout in poverty-alleviation terms and are designed to feed into integrated ocean-poverty assessments rather than to substitute for ecosystem-condition indicators. Empirical illustrations that have driven the indicator design include the Inhambane Bay studies, where small-scale fisheries provide 60–70% of household income and 70–80% of dietary protein in coastal villages; the Lake Illawarra estuary case, where ecosystem degradation translated directly into livelihood loss without the dependency relationship having been measured ex ante; and the Nippon Causeway / Tarawa case, where infrastructure decisions taken without dependency evidence led to documented harm to subsistence harvesting (Burnside, 2026)[2]. These cases — where ex ante dependency evidence would have changed the decision — are the standing reference for the indicator set.

DRAFT

4.1.3 Institutional coordination and inter-agency data reconciliation

¶1 Compilation of TG-2.3 indicators draws on data held by multiple agencies — the NSO (household and labour surveys, census), fisheries ministry (catch, vessel, licence registers), tourism ministry or TSA compiler (visitor arrivals, accommodation employment), environment or marine affairs ministry (MPA, stock, and ecosystem-condition data), and community-held sources legitimised under Section 4.1.1. Without an explicit coordination arrangement, the dependency indicators will either be incompilable (because no single agency holds the data) or will be compiled inconsistently between cycles (because the agency lead changes). The 2025 SNA provides extensive guidance on inter-agency coordination for satellite accounts (Chapter 21, especially para 21.28; Chapter 4 paras 4.252–4.254), and the SEEA-EA Chapter 14 and SEEA-AFF set out the analogous arrangements for environmental-economic and food-system accounts.

¶2 **Compiling lead.** The default compiling lead for TG-2.3 indicators is the **National Statistical Office**, in its role as the institutional custodian of the survey programme on which the indicators principally depend (Section 4.1.2) and the convening authority for satellite-account work under SNA 2025 Chapter 21. Where this default does not hold — for example, where the NSO does not have the marine-domain capacity or where another agency (a national ocean accounts unit, a Ministry of the Sea, a Pacific Community statistical hub, a research institute compiling on behalf of government) is better placed — the alternative arrangement must be documented and the rationale recorded, consistent with **TG-0.1 General Introduction to Ocean Accounts** §3.7 on compiling-lead determination.

¶3 **Minimum coordination arrangement.** A standing coordination mechanism is required. The minimum acceptable form is a written instrument — a standing inter-agency working group or a Memorandum of Understanding — with the NSO and at minimum the fisheries, tourism, and environment portfolios as parties, with a documented process for incorporating community-held sources legitimised under Section 4.1.1. The instrument should specify:

- ¶4 data flows and update cycles;
- ¶5 the agency authoritative for each variable;
- ¶6 the procedure for resolving inconsistencies between sources; and
- ¶7 the publication and revision schedule.

¶8 SNA 2025 Chapter 4 paras 4.252-4.254 set out the institutional sectoring underlying these arrangements.

¶9 **Reconciliation hierarchy for same-population-in-multiple-registries.** A common compilation problem is that the same population (typically small-scale fishers) appears in multiple registries (fisheries licence register, LFS, fishing-cooperative records, community catch registers) with different counts and different coverage definitions. The recommended reconciliation hierarchy is:

1. ¶10 **Source closest to the dependency relationship.** Where one source is operationally closer to the activity being measured (e.g. a community catch register for subsistence harvesting; a fisheries licence register for licensed commercial activity), that source takes precedence for the relevant sub-population.
2. ¶11 **Broadest informal coverage where (1) does not discriminate.** Where multiple sources are equally close to the relationship, the source with the broadest informal coverage takes precedence; the resulting gap relative to narrower sources is recorded in metadata.
3. ¶12 **Cross-tabulation where unique IDs permit.** Where personal or vessel identifiers allow linkage across registers, the indicator is compiled from the cross-tabulated unique-person count rather than from any single register.
4. ¶13 **Reported as range where unresolvable.** Where steps 1-3 do not resolve the inconsistency, the indicator is reported as a range bounded by the highest and lowest defensible source counts, with metadata identifying the sources and the unresolved coverage difference.

¶14 **Concordance table.** Each compilation cycle should publish a concordance table mapping the operational definitions used in the dependency indicators to ISIC Rev. 4 industry codes, ISCO occupation codes, national fisheries register categories, and the TSA tourism-characteristic-activity classification. This concordance is the practical instrument that makes inter-agency reconciliation possible and is consistent with the satellite-account requirements in SNA 2025 Chapter 21 paras 21.59-21.62 and Chapter 16 on labour.

4.2 Compilation Procedure

¶1 **Note on thresholds:** All thresholds in this section are illustrative. Compilers must derive context-specific thresholds using local data and expert judgement before applying them to national or sub-national reporting.

¶2 **Note on community sense-checking.** The compilation procedure below produces preliminary indicator values from secondary data. These preliminary values must be sense-checked with communities in the spatial unit before publication. Sense-checking is not a sign-off: findings from sense-check engagements must be capable of revising preliminary values, flagging them with qualitative annotation, or adding supplementary indicators. A sense-check that cannot change the published account is not meeting the standard. Sense-check engagements at the compilation stage build on the source-level sense-check described in Section 4.1.1 and should, where possible, reach the same groups consulted at that stage. Compilers should treat findings under one of four categories, documenting which applies to each indicator:

DRAFT

1. ¶3 **Confirmation.** Community feedback corroborates the preliminary value. The indicator is published with metadata recording the validation date and groups consulted.
2. ¶4 **Calibration within documented bounds.** A specific component is identified as over- or under-stated for a known reason (typically a systematic undercount in the secondary source). The value is revised within a documented range — the secondary source providing one bound, the community estimate providing the other — and published as a range with a reported point estimate. The metadata records the reason for adjustment.
3. ¶5 **Flagging without revision.** The community identifies that the score, whilst numerically defensible from secondary data, misses a dimension that cannot be quantified within the indicator set (for example, spiritual ties to a particular reef, intergenerational transmission of marine knowledge, displacement losses already absorbed). The numerical score is published unchanged with a qualitative annotation explicitly naming what the score does not capture.
4. ¶6 **Supplementation.** A community-identified indicator is added as a supplementary measure alongside the standard set. It does not replace a standard indicator, but appears in the national table and feeds into the next revision of this Circular and the forthcoming Accounting for People Circular [49].

¶7 This section provides a step-by-step procedure for compiling the core livelihood dependency indicators described in Section 3. The procedure assumes that basic ocean economy accounts have been compiled following **TG-3.3 Economic Activity** and that relevant household survey data are available. Compilers should adapt the procedure to national data circumstances.

Step 1: Compile ocean employment dependency ratio

¶1 **Objective:** Measure the share of total employment attributable to ocean-dependent sectors.

¶2 **Data requirements:**

- ¶3 Labour force survey with industry classification at ISIC Rev. 4 4-digit level
- ¶4 Fisheries registry or administrative records for fishing employment
- ¶5 Tourism employment data disaggregated by coastal/marine tourism

¶6 **Procedure:**

1. ¶7
   Extract employment counts for ocean-dependent industries from labour force survey:
   - ¶8 ISIC 0311 (Marine fishing)
   - ¶9 ISIC 0321 (Marine aquaculture)
   - ¶10 Coastal tourism share of ISIC 55 (Accommodation), 56 (Food and beverage services), 79 (Travel agencies)

   Note: ISIC 50 (Water transport) is assigned to the secondary tier, not this direct employment list (see Section 3.2.1 for full ISIC 50 classification).
2. ¶11
   Adjust for informal and subsistence employment using fisheries registry:
   - ¶12 Cross-check survey totals against fishing license/registration counts
   - ¶13 If survey underestimates artisanal/small-scale fishers, apply adjustment factor based on registry coverage
   - ¶14 Document adjustment methodology in metadata

¶15 2a. **Compile post-harvest and value chain employment with sex/gender disaggregation.** Direct-harvest employment counts (sub-step 1) systematically understate the labour engaged in ocean-dependent livelihoods because the post-harvest and shore-based value chain is disproportionately performed by women and persons in informal arrangements. Compilers must compile a separate count of value-chain employment, with the following scope and disaggregation:

DRAFT

- ¶16 **Scope.** Includes ISIC 1020 (seafood processing and preserving), fish marketing and distribution (including in markets, on roadsides, and through intermediated trade), and shore-based and home-based components of the value chain such as gleaning, net-mending, drying, smoking, and informal marketing.
- ¶17 **Mandatory disaggregation.** Sex or gender, per Circular 1 (GESI) guidance and consistent with national data system conventions; and formal/informal employment status.
- ¶18 **Documented where available.** Age, indigeneity, disability, and migration status. Where the underlying survey does not collect these variables, the metadata records the gap rather than treating it as zero coverage.

¶19 Cross-references: **TG-3.13 Gender Equality and Social Inclusion** for the disaggregation framework; **TG-3.15** for the related value-chain treatment. Counts produced under this sub-step are preliminary and remain subject to revision under Section 4.1.1 / Step 1 sub-step 6 community sense-check.

3. ¶20
   Sum employment across ocean industries to derive direct ocean employment total
4. ¶21
   Compute ocean employment dependency ratio:

   > *Ocean employment ratio = Direct ocean employment / Total employment*

5. ¶22
   Report both absolute employment count and percentage share
6. ¶23
   Community sense-check on employment count. Before publishing the ratio, present the disaggregated employment counts (by ISIC category, by sex, by formal/informal status) to community sense-check sessions disaggregated by sex and age. Record findings on whether categories of work are systematically under- or over-counted, particularly informal and gendered work such as gleaning, shore-based processing, and net-mending. Apply the four-category treatment set out at the start of Section 4.2 and document the basis for any revision in metadata.

¶24 **Output:** Ocean employment dependency ratio (percent), with metadata documenting survey source, reference period, any adjustments for informal employment, sex/gender-disaggregated value-chain employment counts (sub-step 2a), and the four-category treatment applied following community sense-check.

Step 2: Compile fish protein dependency ratio

¶1 **Objective:** Measure the contribution of marine-sourced protein to total animal protein supply.

¶2 **Data requirements:**

- ¶3 Food balance sheet or household consumption and expenditure survey
- ¶4 Fish catch statistics (commercial + subsistence)
- ¶5 Protein content conversion factors by species or species group

¶6 **Procedure:**

1. ¶7
   Compile total fish supply from food balance sheet:
   - ¶8 Domestic catch (commercial + estimated subsistence)
   - ¶9 Plus imports, minus exports
   - ¶10 Minus non-food uses (fishmeal, pet food, waste)
   - ¶11 Equals fish available for human consumption (tonnes live-weight equivalent)
2. ¶12

DRAFT

Convert live-weight supply to edible weight using species-specific edible yield coefficients (FAO Food Composition Tables recommended; typical range 0.45–0.65). Where species-level yield data are unavailable, apply a default yield coefficient of 0.50 and flag the indicator as a low-confidence estimate in metadata.

> *Fish available (edible weight, tonnes) = Fish available (live-weight, tonnes) × Edible yield coefficient*

3. ¶13
   Apply protein content factor to edible weight only:

   > *Fish protein supply (tonnes) = Fish available (edible weight, tonnes) × Average protein content factor*

   Use species-specific factors where possible; otherwise apply regional average (typically 0.16–0.20, with 0.18 as common benchmark for edible weight, wet-weight basis per FAO FCT conventions). Protein content factors must not be applied to live-weight or round-weight data.
4. ¶14
   Compile total animal protein supply from food balance sheet:
   - ¶15 Sum protein from meat, fish, dairy, eggs
   - ¶16 Align reference period with fish data
5. ¶17
   Compute fish protein dependency ratio:

   > *Fish protein dependency = Fish protein supply / Total animal protein supply*

6. ¶18
   Compute per capita fish protein:

   > *Per capita fish protein (kg/year) = Fish protein supply / Population*

7. ¶19
   Community sense-check on dietary reliance. Present the preliminary per capita fish protein supply and the protein dependency ratio to disaggregated community sense-check sessions. Pay particular attention to seasonality: where the household consumption survey reference period misses seasonal lows in fish availability, communities can identify this directly and the indicator should be flagged or supplemented with a seasonal range. Where subsistence harvesting is significant, sense-check sessions should verify whether the imputed subsistence component reflects actual household consumption. Apply the four-category treatment and document accordingly.

¶20 **Output:** Fish protein dependency ratio (percent) and per capita fish protein supply (kg/year), with metadata on protein conversion factors, data sources, and the four-category treatment applied following community sense-check.

Step 3: Compile livelihood vulnerability index

¶1 **Objective:** Produce composite vulnerability index for ocean-dependent coastal community using exposure, sensitivity, and adaptive capacity components.

¶2 **Data requirements:**

- ¶3 Spatial data on coastal flood and cyclone risk zones
- ¶4 Household survey with income and asset modules
- ¶5 Coastal community education and employment data

DRAFT

- ¶6 Fish stock status assessments

¶7 **Procedure:**

1. ¶8
   Define the spatial unit for vulnerability assessment:
   - ¶9 Coastal administrative unit (district, municipality)
   - ¶10 Or specific coastal community
   - ¶11 Document spatial boundaries and population
2. ¶12
   Compile and normalise exposure indicators (scale 0–1, higher = greater exposure):
   - ¶13 Flood risk: Share of settlement in 1-in-50-year flood zone
   - ¶14 Cyclone frequency: Annual average cyclone landfalls (past 20 years), normalised by maximum observed
   - ¶15 Stock risk: Share of local catch from stocks assessed as overfished or uncertain
   - ¶16 Compute exposure score as simple average of normalised indicators
3. ¶17
   Compile and normalise sensitivity indicators (scale 0–1, higher = greater sensitivity):
   - ¶18 Income dependence: Average share of household income from fishing/ocean sectors (from household survey)
   - ¶19 Housing quality: Share of households in informal or non-code housing
   - ¶20 Dietary dependence: Share of animal protein from fish (from household consumption survey)
   - ¶21 Compute sensitivity score as simple average of normalised indicators
4. ¶22
   Compile and normalise adaptive capacity indicators (scale 0–1, higher = greater capacity):
   - ¶23 Educational attainment: Average years of schooling, normalised by national average
   - ¶24 Financial inclusion: Share of households with savings account or insurance coverage
   - ¶25 Livelihood diversity: Shannon diversity index of employment across industries, normalised
   - ¶26 Compute adaptive capacity score as simple average of normalised indicators
5. ¶27
   Compute composite vulnerability index:

   > *Vulnerability index = (Exposure + Sensitivity + (1 - Adaptive Capacity)) / 3*

   The formula inverts adaptive capacity (using 1 - AC) because higher capacity reduces net vulnerability. This produces a true 0–1 range where 0 indicates no vulnerability and 1 indicates maximum vulnerability.
6. ¶28
   Interpret result using threshold classification (all thresholds are illustrative — see note at start of Section 4.2):
   - ¶29 0.00–0.33: Low vulnerability
   - ¶30 0.33–0.55: Moderate vulnerability
   - ¶31 0.55–1.00: High vulnerability
7. ¶32
   Community sense-check on component scores and composite index. Present preliminary component scores (exposure, sensitivity, adaptive capacity) and the composite index to disaggregated community sense-check sessions. Three questions structure the engagement:
   - ¶33 Does the composite score reflect lived experience of vulnerability in this place?
   - ¶34 Which component is most over- or under-stated, and why?
   - ¶35 What is missing from the indicator set that the community would include?

DRAFT

The threshold classification (low / moderate / high) is the most consequential element to sense-check, because it drives policy targeting. A community whose composite score falls near a threshold boundary may experience itself as more or less vulnerable than the classification suggests, for reasons the index does not capture; this finding must appear in metadata even where the score itself is unchanged. Apply the four-category treatment to each component and to the composite. Where supplementation occurs — that is, where a community identifies an indicator the index should include — record the supplementary indicator in the national table and flag it for consideration in the next revision of this Circular and in the forthcoming Accounting for People Circular [49].

¶36 **Output:** Composite livelihood vulnerability index (0–1 scale) with component scores, spatial unit definition, interpretation guide, and the four-category treatment applied following community sense-check.

Step 5: Document methodology and metadata

¶1 For all compiled indicators, document:

- ¶2 Data sources (survey instrument, administrative system, reference period)
- ¶3 Estimation methods (calculation formulas, adjustment factors, normalisation procedures)
- ¶4 Limitations and uncertainties (sampling error, coverage gaps, imputation methods)
- ¶5 **Community sense-check engagements:** date, spatial unit, groups consulted (with disaggregation), questions asked, findings recorded, and the four-category treatment (set out at the start of Section 4.2) applied to each indicator
- ¶6 **Supplementary indicators** added through sense-check supplementation, with the rationale for inclusion and a flag for consideration in the next revision of this Circular and in the forthcoming Accounting for People Circular [49]
- ¶7 Quality assessment per **TG-0.7 Quality Assurance**

¶8 **Reference-year metadata block.** A single reference-year field is insufficient for indicators whose underlying sources update at different frequencies. For each compiled indicator, the metadata block must record the following eight fields rather than a single year stamp:

1. ¶9 **Indicator's published reference year** — the year to which the published indicator value is attributed.
2. ¶10 **Anchor source and observation year** — the binding source for the indicator and the year of its underlying observation. The anchor source per indicator is: **HIES** for the livelihood vulnerability index (because the index is sensitivity-led and sensitivity depends on household income and asset variables only the HIES provides); **LFS** for the ocean employment dependency ratio (because it is the only source providing the industry-by-employment cross-tabulation on a comparable basis); **Food balance sheet** for the fish protein dependency ratio. The **Population and Housing Census is not an anchor source** for any TG-2.3 indicator because the inter-censal interval is too long to keep an anchor current; the census is used only to provide small-area population denominators.
3. ¶11 **Every contributing source** — listed with its reference year and update frequency.
4. ¶12 **Temporal gap in years** — the largest difference, in years, between the published reference year and the observation year of any contributing source.
5. ¶13 **Bridging method** — the method used to bring older contributing sources up to the published reference year. The standard method is **proportional Denton temporal disaggregation** (IMF Quarterly National Accounts Manual, Chapter 6), which preserves both the lower-frequency benchmark and the higher-frequency indicator's shape. **Pro rata extrapolation is rejected** as a bridging method because it does not preserve the benchmark's covariance with auxiliary information. On methodology changes in the contributing source, the indicator series is **back-cast** rather than spliced, so that pre- and post-change values remain comparable.

DRAFT

6. ¶14 **Indicator series used for extrapolation** — the higher-frequency series (typically LFS, climate, or stock-status data) used to bring older HIES or FBS observations forward.
7. ¶15 **Update type** — routine update, benchmark update, or comprehensive revision, in the SNA 2025 sense (paras 20.92, 20.95-20.98, 20.36, 20.101; satellite-account treatment in paras 21.59-21.62, 21.67).
8. ¶16 **Confidence flag** — where the temporal gap exceeds five years between the anchor source's observation year and the published reference year, the indicator is flagged as **low confidence** in the publication. Gaps of three to five years are flagged as **medium confidence**, and gaps under three years as **high confidence**.

¶17 A worked example of a vintage label, where the HIES observation is from 2024 but the indicator is published with respect to reference year 2024 in publication year 2026, is: "reference year 2024, vintage 2026, routine update, high confidence". The reference-year metadata block is a publication-side artefact attached to each compiled indicator and is the principal mechanism by which the analytical layer described in Section 4.1.2 stays consistent with the revision conventions of the official statistics on which it is built (see also SNA 2025 paras 21.28 and 21.59-21.62).

¶18 This documentation supports transparency, enables indicator updates in subsequent periods, and provides the evidence base for indicator reform when the Accounting for People Circular is finalised.

Table 2 — Recommended compilation frequency and maximum data vintage

¶1 The dependency indicators in this Circular share survey-side update cycles with the official statistics from which they are derived. Table 2 sets out the recommended compilation frequency and maximum acceptable data vintage for each indicator, together with the primary data source and natural update cycle of that source.

Indicator	Primary data source	Natural update cycle	Recommended compilation frequency	Maximum data vintage	Notes
Ocean employment dependency ratio	Labour Force Survey (LFS)	Annual or biennial	Annual where LFS is annual; otherwise biennial	2 years (annual LFS); 4 years (biennial LFS)	Industry-by-employment cross-tabulation routinely available
Fish protein dependency ratio	Food Balance Sheet (annual) + HIES (3-5 year)	FBS annual; HIES 3-5 year	Annual ratio; HIES-based household-level disaggregation refreshed on HIES cycle	2 years (FBS); 5 years (HIES)	Use FBS as the routine series; refresh household-level component on HIES cycle
Livelihood vulnerability index	HIES (anchor) + annual climate and stock data	HIES 3-5 year; climate and stock annual	Composite re-run annually using updated climate and stock data with most recent HIES; full refresh on HIES cycle	5 years (HIES anchor)	Sensitivity components carry the longest vintage and dominate the index's currency status

¶2 *Table 2: Recommended compilation frequency and maximum data vintage by indicator*

¶3 Two principles govern the practical use of Table 2:

1. ¶4 **Sub-indicators update independently; the composite is re-run on the most recent vintage of each.** A compiler is not required to wait for the slowest-moving input before re-running the composite. The composite is re-run each year using the most recent vintage of each con-

DRAFT

tributing source, with the reference-year metadata block (Step 5) recording the vintage of each contributing input.

2. ¶5 **Over-vintage indicators carry a metadata flag rather than being suppressed.** Where a contributing source has not been refreshed within the maximum vintage in Table 2, the indicator is published with a confidence flag rather than withdrawn. Suppression of an indicator deprives users of the most recent defensible estimate. Flagging preserves the estimate while making its vintage status transparent. This is consistent with SNA 2025 Chapter 21 guidance on satellite-account publication where source vintages differ from the core-account release.

4.3 Worked Example

¶1 Synthetic data for a hypothetical Small Island Developing State (SIDS) illustrate the three core compilation procedures. Compilers should substitute national data sources as described in Section 4.1.

Employment dependency indicators

¶1 **Step 1 — Sum direct ocean employment by sector:**

Sector	Employment (persons)
Fishing (commercial and artisanal)	12,000
Aquaculture	3,500
Coastal tourism	25,000
Total direct ocean employment	**40,500**

¶2 Maritime transport (8,000 persons) is secondary-tier employment (Section 3.2.1) and seafood processing (6,000 persons) is value-chain employment (Section 4.2 Step 1 sub-step 2a). Both are reported separately and are not part of the direct total.

¶3 **Step 2 — Compute the ocean employment ratio:**

> *Ocean employment ratio = Ocean employment / Total employment*

> *= 40,500 / 420,000 = **9.6%***

¶4 **Step 3 — Estimate total ocean-dependent employment using an indirect multiplier:**

¶5 Input-output analysis for the national economy yields an ocean sector employment multiplier of 1.8, meaning that each direct ocean job supports an additional 0.8 jobs in supply chains and induced spending.

> *Total ocean-dependent jobs = 40,500 × 1.8 = **72,900***

> *Total ocean-dependent employment share = 72,900 / 420,000 = **17.4%***

¶6 Compilers should report both the direct ratio (9.6%) and the multiplier-adjusted ratio (17.4%), noting the multiplier source and methodology. Multiplier estimates are sensitive to the scope of industries included and should be validated against input-output tables as described in **TG-3.3 Economic Activity**.

DRAFT

Nutritional dependency indicators

¶1 **Step 1 — Estimate fish available for human consumption:**

¶2 The food balance sheet reports annual fish supply of 45,000 tonnes (live-weight equivalent) after accounting for imports, exports, and non-food uses.

¶3 **Step 2 — Convert live-weight supply to edible weight:**

¶4 Apply an edible yield coefficient to convert from live-weight to the edible portion. Using a yield coefficient of 0.50 (appropriate as a default where species-level data are unavailable; compilers should use species-specific FAO FCT coefficients where possible):

> *Fish available (edible weight) = 45,000 tonnes × 0.50 = **22,500 tonnes edible weight***

¶5 **Step 3 — Apply protein content factor to edible weight:**

> *Fish protein supply = Fish available (edible weight) × Average protein content factor*

> *= 22,500 tonnes × 0.18 = **4,050 tonnes fish protein***

¶6 The protein content factor of 0.18 (18% of edible weight, wet-weight basis per FAO FCT conventions) is a standard conversion factor for mixed fish species; compilers should adjust based on national catch composition (edible-weight-only application: Section 4.2 Step 2).

¶7 **Step 4 — Compute the fish protein dependency ratio:**

> *Fish protein dependency ratio = Fish protein supply / Total animal protein supply*

> *= 4,050 / 32,000 = **12.7%***

¶8 **Step 5 — Compute per capita fish protein supply:**

> *Per capita fish protein = Fish protein supply / Population*

> *= 4,050 tonnes / 2.1 million persons = **1.93 kg per capita per year***

¶9 A fish protein dependency ratio of 12.7% indicates meaningful nutritional reliance on marine resources. Values above 20% are commonly used as thresholds for identifying fish-dependent populations. Per capita fish protein supply can be compared against FAO global averages (approximately 3.3 kg per capita per year) to contextualize national dependency levels. Note that the two-stage conversion (live-weight to edible weight, then edible weight to protein) is essential for comparability: omitting the edible weight step would overstate fish protein supply by approximately 100% in this example.

Livelihood vulnerability index

DRAFT

¶1 A composite livelihood vulnerability index aggregates exposure, sensitivity, and adaptive capacity indicators into a single summary measure, following the IPCC vulnerability framework referenced in Section 3.6 in its earlier (AR4) form, which places exposure inside vulnerability; the IPCC Sixth Assessment Report treats exposure as a separate determinant of risk alongside hazard and vulnerability. Each component is normalised to a 0–1 scale where higher values indicate greater exposure, greater sensitivity, or greater adaptive capacity respectively.

¶2 **Step 1 – Compile component scores for a coastal fishing community:**

¶3 Note: This example uses a reduced indicator set for brevity. Compilers should include all indicators listed in the compilation procedure (Section 4.2), including stock risk for exposure and dietary dependence for sensitivity.

Component	Sub-indicator	Score
Exposure	Flood risk (share of settlement in 1-in-50-year flood zone)	0.68
	Cyclone frequency (events per decade, normalised)	0.76
	Exposure average	**0.72**
Sensitivity	Income dependence on fishing (% of household income)	0.70
	Housing quality (% informal or non-code construction)	0.60
	Sensitivity average	**0.65**
Adaptive capacity	Educational attainment (years, normalised)	0.50
	Savings and insurance coverage (% of households)	0.35
	Alternative livelihood options (diversity index)	0.50
	Adaptive capacity average	**0.45**

¶4 **Step 2 – Compute the composite vulnerability index** (apply the formula from Section 4.2 Step 5):

> *= (0.72 + 0.65 + (1 - 0.45)) / 3 = (0.72 + 0.65 + 0.55) / 3 = 1.92 / 3 = **0.64***

DRAFT

¶5 **Step 3 – Interpret the result:**

¶6 A vulnerability index of 0.64 indicates high vulnerability (formula inversion: Section 4.2 Step 5). Applying the illustrative threshold classification from Section 4.2 Step 6:

- ¶7 Values below 0.33 suggest low vulnerability
- ¶8 Values between 0.33 and 0.55 suggest moderate vulnerability
- ¶9 Values above 0.55 suggest high vulnerability warranting priority policy attention

¶10 The example community scores high on exposure (0.72) and sensitivity (0.65) but has limited adaptive capacity (0.45), driven primarily by low savings and insurance coverage (0.35). Policy interventions targeting financial inclusion and livelihood diversification would improve adaptive capacity and reduce the composite vulnerability score.

¶11 For guidance on weighting, normalisation methods, and quality assurance of composite indices, see **TG-2.1 Indicator Design Principles** and **TG-0.7 Quality Assurance**.

4.4 Decision Use Cases

¶1 This section describes the policy decision contexts where livelihood dependency indicators compiled following this Circular directly inform management choices.

Use Case 1: Coastal poverty targeting

¶1 **Decision context:** A national poverty reduction programme seeks to identify coastal communities requiring targeted support. Standard poverty headcount data exist but do not reveal which poor households also face high exposure to ocean ecosystem degradation.

¶2 **Dependency indicators used:**

- ¶3 Ocean employment dependency ratio by coastal administrative unit
- ¶4 Fish protein dependency ratio by household consumption survey cluster
- ¶5 Livelihood vulnerability index combining exposure, sensitivity, and adaptive capacity

¶6 **Application:** Combine poverty mapping with dependency indicators to identify communities that are both poor and highly dependent on ocean ecosystems. Prioritize these "high-dependency, high-poverty" communities for interventions addressing both poverty and ecosystem resilience. Communities with high dependency but low poverty may require different policy responses focused on sustaining livelihoods rather than poverty alleviation.

¶7 **Policy outcome:** Improved targeting of social protection, livelihood diversification programmes, and ecosystem restoration investments to communities where both poverty and ecosystem dependency are high.

Use Case 2: Just transition planning for fisheries reform

¶1 **Decision context:** A country is implementing new fisheries regulations to reduce overfishing, which will reduce total allowable catch and eliminate some fishing licenses. Policy-makers need to identify which communities and workers will be most affected and design compensation and transition support.

¶2 **Dependency indicators used:**

- ¶3 Employment dependency indicators by fishing community (direct, indirect, induced employment)
- ¶4 Share of household income from fishing activities
- ¶5 Employment characteristics (age, sex, educational attainment, alternative skill sets)
- ¶6 Adaptive capacity indicators (access to credit, social protection coverage)

DRAFT

¶7 **Application:** Map the spatial distribution of fishing-dependent employment and household income shares against the proposed license reductions. Identify communities where a high proportion of employment depends on fishing (for example, >30%, though compilers should establish context-specific thresholds based on national circumstances) and where adaptive capacity (education, alternative skills) is low. Design differentiated transition packages: early retirement for older fishers near retirement age; retraining and job placement for younger workers with transferable skills; direct income support for households with high fishing income dependency and limited alternatives.

¶8 **Policy outcome:** Socially equitable fisheries reform that protects livelihoods while achieving sustainability objectives, with compensation and support tailored to community-specific dependency profiles.

Use Case 3: Food security monitoring in coastal zones

¶1 **Decision context:** A Ministry of Health monitors national nutrition indicators and seeks to understand whether coastal populations face distinct food security risks related to marine ecosystem change or fishing access restrictions.

¶2 **Dependency indicators used:**

- ¶3 Fish protein dependency ratio by region
- ¶4 Share of households relying on subsistence fishing
- ¶5 Nutritional quality indicators (contribution to micronutrient intake)

- ¶6 Price volatility of marine food products

¶7 **Application:** Identify coastal regions where a high share of animal protein comes from fish (for example, >40%, though compilers should establish context-specific thresholds based on national circumstances) and where subsistence fishing provides a substantial share of household consumption (for example, >20%). Establish nutrition surveillance in these high-dependency zones to track changes in dietary adequacy alongside monitoring of fish stock status and coastal access. If fish protein dependency is high and fish stocks are declining, trigger contingency food security responses (school feeding programmes with alternative protein sources, nutrition supplementation, support for alternative protein production).

¶8 **Policy outcome:** Proactive food security interventions in fish-dependent populations, preventing malnutrition before it occurs by linking nutrition surveillance to ecosystem condition monitoring.

Use Case 4: Marine protected area design with livelihood safeguards

¶1 **Decision context:** A conservation agency plans to expand marine protected areas (MPAs) to meet biodiversity targets, but must ensure that MPA boundaries and management rules do not disproportionately harm fishing-dependent communities.

¶2 **Dependency indicators used:**

- ¶3 Spatial distribution of fishing effort and subsistence harvesting
- ¶4 Cultural dependency indicators (traditional marine tenure systems, culturally significant sites)
- ¶5 Income and employment dependency by coastal community
- ¶6 Alternative livelihood options available in affected areas

¶7 **Application:** Overlay proposed MPA boundaries with maps of fishing dependency and cultural significance. Identify coastal communities that currently derive >50% of income from areas proposed for strict protection. Adjust MPA boundaries to avoid complete exclusion of high-dependency communities, or design co-management zones where sustainable fishing and cultural practices continue under community governance. Where displacement is unavoidable, quantify affected livelihoods and design compensation mechanisms including alternative livelihood support and benefit-sharing from MPA tourism revenues.

¶8 **Policy outcome:** Conservation gains achieved without imposing uncompensated livelihood losses, with MPA governance structures that recognise and support the dependencies of coastal communities on marine ecosystems.

Use Case 5: Indigenous customary sea rights (deferred — placeholder)

¶1 A customary sea rights use case (Indigenous tenure, FPIC, UNDRIP) is in development. Drafting is deferred until Indigenous co-authors and reviewers are confirmed as part of the writing team with authority over the text, consistent with the principle stated in **TG-3.6 Traditional Knowledge Accounts** that guidance on Indigenous knowledge and tenure should be written with, not about, the communities concerned. Practitioners from the jurisdictions named in the original proposal (Fiji, Vanuatu, and ideally others such as Aotearoa and the Torres Strait) would be the appropriate people to lead or co-lead this use case. The omission is recorded here as a finding rather than a gap: writing a use case on customary sea rights without Indigenous co-authors would contradict the framing this Circular already adopts elsewhere on Indigenous data sovereignty and community-led methods.

Use Case 6: Post-disaster needs assessment (PDNA)

¶1 **Decision context:** Following a major cyclone, storm surge, or coastal flooding event, a government convenes a Post-Disaster Needs Assessment to quantify damage and loss across affected sectors and to plan recovery. The PDNA Fisheries and Coastal Livelihoods sector requires evidence on the dependent population, the magnitude of livelihood loss, and the recovery cost. The Sendai

DRAFT

Framework for Disaster Risk Reduction 2015-2030 [3] frames this work as the operational expression of disaster resilience commitments. TG-2.3 supplies the dependency baseline against which damage and loss are measured.

¶2 **Dependency indicators used (PDNA phase mapping):**

PDNA phase	Indicators required	TG-2.3 source
Baseline (pre-event)	Ocean employment dependency ratio; fish protein dependency ratio; livelihood vulnerability index	Compiled per Section 4.2
Rapid assessment (72-hour)	Pre-event indicator values, affected-population overlay	Pre-existing values + spatial extent of event
Damage and loss	Loss of employment, loss of subsistence harvest, dependency-weighted loss valuation	Pre-event dependency × event extent
Recovery planning	Vulnerability index components; integration with the social protection register (SDG 1.3.1)	Section 3.6 / 4.2

¶3 **Application:** TG-2.3 indicators supply the pre-event baseline against which the PDNA Fisheries and Coastal Livelihoods sector module quantifies damage and loss. The dependency indicators are inputs to the PDNA methodology — they do not replace the World Bank / UN / EU PDNA Fisheries and Coastal Livelihoods sector guidance note (the sector-specific damage and loss costing methodology). The illustrative magnitudes documented in the Inhambane Bay case (small-scale fisheries providing 60-70% of household income and 70-80% of dietary protein in coastal villages; Burnside, 2026) [2] indicate the order of magnitude that dependency baselines can take in SSF-reliant coastal economies and the corresponding scale of livelihood loss that an event in such a setting can impose.

¶4 **Policy outcome:** PDNA recovery costings that reflect the dependency baseline of affected populations, supporting Loss & Damage Fund applications and recovery resourcing decisions that are calibrated to the magnitude of pre-event reliance on ocean ecosystems.

> *Note on scope. The PDNA-sector worked-table crosswalk in this use case, including its precise alignment with the most recent World Bank / UN / EU PDNA Fisheries and Coastal Livelihoods sector guidance note, is to be confirmed in consultation with the GOAP Secretariat. The use case is therefore presented as the operational frame for the indicator set rather than as a substitute for the PDNA sector methodology.*

DRAFT

Use Case 7: Marine spatial planning and ESIA

¶1 **Decision context:** A marine spatial planning (MSP) authority and a project developer have a concurrent need for dependency evidence over the same spatial area: the MSP authority requires the human-uses analysis to underpin allocation of the marine area between competing uses (Step 4 of the IOC-UNESCO MSP guidance [50], [51]), whilst the developer requires an Environmental and Social Impact Assessment (ESIA) under IFC Performance Standard 5 [52] and the Equator Principles IV [53] to identify economically displaced persons and design livelihood restoration. The use case is framed throughout from the government / MSP-authority perspective, with the ESIA application as a downstream use of the same indicator stack.

¶2 **Dependency indicators used:**

- ¶3 Spatial distribution of fishing-effort-based employment, by fishing ground
- ¶4 Subsistence-harvesting areas at sub-administrative spatial resolution
- ¶5 Fish protein dependency by coastal administrative unit
- ¶6 Livelihood vulnerability index by coastal community

¶7 **Application (MSP):** Under Step 4 of the IOC-UNESCO MSP guidance, the dependency indicators populate the human-uses analysis that the spatial allocation depends on. The MSP authority overlays the dependency layers against proposed allocations — offshore wind concessions, MPA zoning, shipping lanes, aquaculture sites — to identify spatial conflicts and the populations whose livelihoods the allocation will displace, sustain, or transform.

¶8 **Application (ESIA / IFC PS5):** The same indicator stack supplies the ESIA's baseline. Specifically, it identifies the economically displaced persons whose livelihood restoration the developer is obliged to plan; it provides the pre-project baseline against which livelihood restoration is measured (PS5 paragraph 28); and the livelihood vulnerability index, in conjunction with the dependency indicators, supports identification of "particularly vulnerable" status (PS5 paragraph 27).

¶9 **Worked illustration — offshore-wind concession.** A 200 km² concession overlaps a fishing ground that supplies 18% of the affected coastal community's fishing effort, in a community whose livelihood vulnerability index is greater than 0.55. The MSP authority's response is either a fisheries-compatible turbine array (with spacing, foundations, and access arrangements that retain fishing access) or an offset package tied to the dependency magnitude (livelihood restoration funded at a level scaled to the 18% effort displaced and the vulnerability classification of the affected community). Cross-reference: this use case is the developer-and-MSP-authority counterpart to Use Case 4 (MPA design with livelihood safeguards), and shares the underlying spatial dependency methodology.

¶10 **Policy outcome:** MSP allocations and ESIA mitigation plans that are calibrated to the dependency magnitude they affect, reducing the incidence of post-allocation livelihood disputes and supporting the IFC PS5 / Equator Principles IV obligations on economically displaced persons.

Use Case 8: Fishing access agreements (DWFN / SIDS)

¶1 **Decision context:** A Small Island Developing State government is renewing an access agreement with a distant-water fishing nation (DWFN) under, for example, the Pacific Islands Forum Fisheries Agency Vessel Day Scheme [54], with PNA Office minimum benchmark prices [55] as a floor. The negotiating government requires evidence on the social and nutritional floor (the level of access below which domestic livelihoods and food security are compromised) and on the fiscal floor (the level of access fees below which the agreement does not deliver an adequate share of resource rent to the coastal state).

¶2 **Dependency indicators used:**

- ¶3 Fish protein dependency ratio (social floor) — minimum domestic catch needed to maintain dietary protein supply
- ¶4 Government revenue dependency on fisheries (fiscal floor) — access-fee share of government revenue, which in some Pacific SIDS exceeds 30–40% of total government revenue
- ¶5 Ocean employment dependency, specifically in domestic processing, transhipment, and crewing
- ¶6 Livelihood vulnerability index for SSF-dependent coastal communities

¶7 **Application:** The dependency indicators inform the negotiation in three ways. First, the fish protein dependency ratio establishes the social floor below which domestic catch retained for local consumption must not fall. Second, the government revenue dependency indicator establishes the fiscal floor against which access-fee levels are evaluated, with the PNA Vessel Day Scheme benchmark prices as a defensible minimum. Third, the employment dependency in domestic processing and transhipment indicates whether the agreement should require minimum domestic landings, crewing, or transhipment to sustain shore-based employment, consistent with FAO Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries (the SSF Guidelines), Chapters 5 and 7 [56].

DRAFT

¶8 **Note on SNA 2025 asymmetry.** Under SNA 2025, output from a DWFN vessel is allocated to the residency of the vessel operator (the DWFN), whilst access fees received by the coastal state are recorded as resource rent. Conventional GDP accounting therefore systematically understates the economic significance of the resource to the coastal state. This is precisely the asymmetry that TG-2.3 dependency indicators are designed to surface: by quantifying domestic livelihood, protein, and revenue dependency on the resource, the indicators provide the evidence base that GDP accounts cannot. Distributional consequences for domestic SSF (gear conflict, stock pressure, displacement of local fleets) cross-reference Use Case 2 on just transition and, where relevant, the deferred Use Case 5.

¶9 **Policy outcome:** Access-agreement renewals in which the negotiating government has explicit, defensible floors for domestic catch retention, access-fee levels, and shore-based employment, replacing the present asymmetric position in which DWFNs are typically the better-resourced negotiating party.

Use Case 9: Climate adaptation planning and NAP

¶1 **Decision context:** A government compiles a National Adaptation Plan (NAP) and prepares finance submissions to the Green Climate Fund, the Adaptation Fund, and the Loss and Damage Fund. The NAP needs ocean-dependent evidence over a 10-20 year planning horizon, aligned with the Nationally Determined Contribution (NDC) cycle.

¶2 **Dependency indicators used:**

- ¶3 Livelihood vulnerability index components (exposure, sensitivity, adaptive capacity)
- ¶4 Ocean employment dependency ratio
- ¶5 Fish protein dependency ratio
- ¶6 Coastal protection dependency (Section 3.4 storm-mitigation service flow)
- ¶7 TG-2.1 ecosystem extent and condition indicators (biophysical input)

¶8 **Application:** A trajectory analysis overlays current dependency indicators against projected ecosystem condition. Projections are drawn from IPCC AR6 regional climate projections, downscaled where available, and from national stock-status assessments under climate scenarios. The product of "today's dependency" and "projected ecosystem trajectory" identifies populations and sectors with the greatest projected livelihood loss over the planning horizon, which in turn drives the NAP's adaptation-investment prioritisation and the loss-and-damage component of climate-finance submissions.

¶9 **Indicator → climate-finance criterion mapping:**

TG-2.3 indicator	NAP / climate-finance criterion
Livelihood vulnerability index	Particularly Vulnerable Group identification
Ocean employment dependency × projected ecosystem condition	Just transition investment case
Fish protein dependency × projected stock trajectory	Food-security adaptation investment case
Coastal protection dependency × SLR projection	Nature-based coastal protection investment case

¶10 **Distinction from Use Case 2.** Use Case 2 (just transition for fisheries reform) addresses policy-triggered transition (a regulator-imposed reduction in total allowable catch). Use Case 9 addresses ecosystem-driven transition (climate-driven change in ecosystem condition), and is loss-and-damage oriented rather than reform-compensation oriented. Both use the same dependency indicators, whilst the trigger and the policy instrument differ.

¶11 **Data limitations.** Climate-projection-based use of dependency indicators must be presented as scenario ranges, not point estimates. The community sense-check protocol established in

DRAFT

Section 4.1.1 applies to the projected-change scenarios: communities have direct evidence on whether the trajectory implied by a climate scenario is consistent with their observation of stock, season, and storm patterns over the recent past, and this evidence must be capable of revising the scenario set used in the NAP.

¶12 **Policy outcome:** NAP investment portfolios and climate-finance submissions that are calibrated to projected dependency loss rather than to current-condition dependency alone, with explicit scenario uncertainty surfaced rather than collapsed into point estimates.

Use Case 10: TNFD nature-related disclosure

¶1 **Decision context:** A government statistical agency, regulator, or financial system supervisor uses national or sub-national dependency indicators to support the Taskforce on Nature-related Financial Disclosures (TNFD) LEAP framework[57] — Locate, Evaluate, Assess, Prepare — particularly the Locate and Evaluate phases at national and sub-national scale.

¶2 **Dependency indicators used:**

- ¶3 Spatial distribution of ocean employment and subsistence harvesting (Locate)
- ¶4 Fish protein dependency ratio by region (Evaluate)
- ¶5 Livelihood vulnerability index by coastal community (Evaluate)
- ¶6 Coastal protection dependency from Section 3.4 (Locate / Evaluate)

¶7 **Application:** National and sub-national TG-2.3 indicators serve as **screening inputs and contextual baselines** for TNFD-aligned disclosure at the entity level. They locate the high-dependency, high-vulnerability geographies that financial institutions and corporates should examine in greater detail under the Locate and Evaluate phases, and they provide the contextual baseline against which entity-level data are interpreted.

¶8 **Constraints on use.** Three constraints govern this use case and must be made explicit in any application:

1. ¶9 **Scale mismatch.** TG-2.3 indicators are compiled at national or sub-national scale. They do not, by themselves, satisfy project-level due diligence requirements. Where a district-level indicator flags a population as high-dependency or high-vulnerability, the appropriate response is finer-scale data collection at the affected community, not treatment of the national or district indicator as sufficient.
2. ¶10 **IFC PS7 is a safeguard standard, not a measurement framework.** TG-2.3 indicators inform the screening process by which Indigenous Peoples-related risk is identified. They do not meet PS7 obligations. PS7 obligations — including Free, Prior and Informed Consent — attach at the project level and to the entity undertaking the activity, and they require entity-level due diligence consistent with IFC PS7[58].
3. ¶11 **Deferred-use-case boundary.** This use case must not pre-empt deferred Use Case 5 on Indigenous customary sea rights, particularly given the PS7 FPIC provisions. Any TNFD-disclosure application that engages Indigenous tenure, knowledge, or rights is bound by the principle stated under Use Case 5: drafting and use must be led by the communities concerned, with their authority over the text.

> *Note on scope. The scope of this use case — the extent to which TG-2.3 indicators can be used to support TNFD disclosure beyond screening, and the boundary between disclosure use and the deferred Indigenous use case — is to be confirmed in consultation with the GOAP Secretariat.*

¶12 **Policy outcome:** A defensible boundary for the use of national and sub-national ocean dependency indicators in TNFD-aligned disclosure: as screening inputs that direct entity-level due diligence rather than as substitutes for it.

DRAFT

Use Case 11: Scenario analysis (cross-cutting)

¶1 **Decision context:** A government, regulator, or research institute requires a defensible mechanism for asking "what if" questions of the dependency indicator set — for example, "what would the ocean employment dependency ratio equal if the total allowable catch fell by 30%?" — without overstating the analytical confidence of the answer. The use case is cross-cutting: it sits alongside the policy-specific use cases above and supports them with a common scenario-analysis frame.

¶2 **Methodological frame.** This use case is framed as a sensitivity table, not a predictive model. The Circular's stance against causal inference from cross-sectional dependency indicators (Section 3.6.5; Section 4.2) is preserved: a scenario analysis built on these indicators reports the magnitude of indicator change implied by a given input change, under stated and explicit assumptions, and does not represent itself as a forecast of the policy outcome.

¶3 **Indicator linkages.** A scenario passes through three Circulars in sequence: biophysical inputs from **TG-2.1 Biophysical Indicators** (stock, extent, condition); ecosystem service flows from **TG-3.2 Flows from Environment to Economy** (the service-flow transformation); and the social outcomes that TG-2.3 measures (employment, protein, vulnerability). All three core TG-2.3 indicators are addressed — the scenario frame is not restricted to a single indicator. The synthetic SIDS figures in Section 4.3 (40,500 direct ocean employment; 4,050 tonnes fish protein supply; vulnerability index 0.64) provide the parameter base for the worked scenarios below.

¶4 **Worked example — TAC reduction.** Using the Section 4.3 SIDS parameters, a 30% reduction in TAC propagates through the indicator set as follows. Direct ocean employment in fishing falls by approximately 3,600 jobs (30% of 12,000), reducing the ocean employment dependency ratio from 9.6% to approximately 8.8% before multiplier effects. The fish protein dependency ratio is recomputed against a reduced domestic catch input to the food balance sheet. Sensitivity to the trade response is large, and the scenario must report a range bounded by full import substitution at one end and unsubstituted domestic shortfall at the other. The livelihood vulnerability index increases through both the sensitivity channel (income dependence on a contracting sector) and, indirectly, through the adaptive-capacity channel as livelihood diversity is forced to adjust on a shortened time frame.

¶5 **Explicit limitations.**

- ¶6 The composite vulnerability index has no internationally agreed statistical endorsement. Scenario analysis using the index is therefore exploratory in character and must report the input weights, the normalisation choice, and the threshold classification used.
- ¶7 The multiplier estimates underlying induced and indirect employment in the Section 4.3 worked example must be validated against national input-output tables before being used in scenario analysis, consistent with **TG-3.3 Economic Activity**.
- ¶8 Scenario analysis on dependency indicators does not substitute for behavioural modelling of the response of fishers, processors, and households to the input change. It quantifies the indicator-level consequence of an assumed input change, not the dynamic response.

¶9 **Policy outcome:** A defensible cross-cutting tool for scenario interrogation of the dependency indicator set, preserving the Circular's anti-causal stance while allowing decision-makers to bound the magnitude of indicator change implied by alternative input assumptions.

4.5 Spatial considerations

¶1 Livelihood dependencies are spatially concentrated in coastal communities, requiring attention to geographic disaggregation:

- ¶2 Compile indicators for coastal administrative units separately from national totals
- ¶3 Align social data boundaries with marine spatial units used in environmental accounts
- ¶4 Identify hotspots where high dependency coincides with ecosystem stress

DRAFT

4.6 Temporal considerations

¶1 Dependencies may vary seasonally (monsoon fishing patterns, tourism seasons) and change over time (shifts in employment structure, declining fish stocks). Time series data enable:

- ¶2 Identification of seasonal vulnerability periods
- ¶3 Tracking of long-term dependency trends
- ¶4 Assessment of livelihood transitions

5. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

6. References

¶1 **Section 3.4 (illustrative composite) references:**

- ¶2 Arkema, K. K. et al. (2013). "Coastal habitats shield people and property from sea-level rise and storms." *Nature Climate Change* 3: 913–918.
- ¶3 McGranahan, G., Balk, D., & Anderson, B. (2007). "The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones." *Environment and Urbanization* 19(1): 17–37.
- ¶4 Adger, W. N. et al. (2005). "Successful adaptation to climate change across scales." *Global Environmental Change* 15(2): 77–86.
- ¶5 Brooks, N., Adger, W. N., & Kelly, P. M. (2005). "The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation." *Global Environmental Change* 15(2): 151–163.
- ¶6 Tol, R. S. J. & Yohe, G. W. (2004). "The weakest link hypothesis for adaptive capacity: an empirical test." Working paper.
- ¶7 Beck, M. W. & Lange, G.-M. (eds) (2016). *Managing Coasts with Natural Solutions: Guidelines for Measuring and Valuing the Coastal Protection Services of Mangroves and Coral Reefs.* World Bank WAVES Technical Paper. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/995341472708337982 (https://documents.worldbank.org/en/publication/documents-reports/documentdetail/995341472708337982).
- ¶8 Menéndez, P., Losada, I. J., Beck, M. W., et al. (2018). "Valuing the protection services of mangroves at national scale: The Philippines." *Ecosystem Services* 34: 24–36. https://doi.org/10.1016/j.ecoser.2018.09.005 (https://doi.org/10.1016/j.ecoser.2018.09.005).
- ¶9 Australian Bureau of Statistics (2022). *National Ecosystem Accounts: Experimental Estimates, Methodology* – coastal protection account. https://www.abs.gov.au/methodologies/national-ecosystem-accounts-experimental-estimates-methodology/2020-21 (https://www.abs.gov.au/methodologies/national-ecosystem-accounts-experimental-estimates-methodology/2020-21).
- ¶10 Guannel, G. et al. InVEST Coastal Vulnerability Model documentation (Natural Capital Project, Stanford University).
- ¶11 Climate Central. CoastalDEM high-resolution coastal digital elevation product.

FOOTNOTES

1. ¶1 FAO, The State of World Fisheries and Aquaculture 2024. Globally, fisheries and aquaculture employ over 60 million people, with hundreds of millions more dependent on the sector for nutrition and livelihoods.
2. ¶2 Burnside, D. (2026). *Integrated Ocean-Poverty Account Framework.* Working paper; cited illustrative cases (Inhambane Bay; Lake Illawarra; Nippon Causeway / Tarawa) provide the empirical motivation for the poverty-allevi-

DRAFT

ation framing and integration-with-existing-survey-systems approach adopted in Section 1, Section 4.1.2, and Use Case 6.

3. ¶3 UNDRR (2015). *Sendai Framework for Disaster Risk Reduction 2015-2030.* Adopted by the UN General Assembly in resolution A/RES/69/283. The Framework provides the policy reference under which TG-2.3 dependency indicators feed disaster risk reduction, resilience planning, and Loss & Damage processes (see Use Case 6).
4. ¶4 United Nations, Transforming our world: the 2030 Agenda for Sustainable Development, SDG Target 2.3. "By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers."
5. ¶5 United Nations, Transforming our world: the 2030 Agenda for Sustainable Development, SDG Target 14.7.
6. ¶6 United Nations et al. (2025). System of National Accounts 2025, Chapter 16 on Labour. Provides comprehensive guidance on employment status, remuneration of employees, and the distinction between formal and informal employment.
7. ¶7 SEEA Ecosystem Accounting, para. 2.15. "Benefits are the goods and services that are ultimately used and enjoyed by people and society. The benefits to which ecosystem services contribute may be captured in current measures of production (e.g. food, water, energy, recreation) or may be outside such measures."
8. ¶8 SEEA Ecosystem Accounting, para. 2.14. "Ecosystem services are the contributions of ecosystems to the benefits that are used in economic and other human activity."
9. ¶9 SF-MST, para. 1.1. "Given the range of direct and indirect effects and the wide spectrum of stakeholders involved, there is a need for an integrated approach to tourism development, management and monitoring."
0. ¶10 System of National Accounts 2025, Preface. The 2025 SNA broadens the national accounts framework "to better account for elements affecting wellbeing and sustainability."
1. ¶11 SF-MST, para. 2.57. The framework distinguishes "direct effects" from "indirect and induced effects" for measuring sustainability.
2. ¶12 SEEA Ecosystem Accounting, para. 2.31.
3. ¶13 SF-MST, Chapter 3. "Linkages between measures of employment in tourism" provides detailed guidance adaptable to ocean sector employment.
4. ¶14 United Nations, Global indicator framework for SDGs, Indicator 14.7.1.
5. ¶15 United Nations, 2030 Agenda for Sustainable Development, SDG Target 2.3.
6. ¶16 SEEA for Agriculture, Forestry and Fisheries, para. 2.
7. ¶17 United Nations, 2030 Agenda for Sustainable Development, SDG Target 8.9.
8. ¶18 SF-MST, para. 5.80.
9. ¶19 SF-MST, para. 2.57.
0. ¶20 SF-MST, para. 2.58.
1. ¶21 SF-MST, para. 2.58.
2. ¶22 System of National Accounts 2025, Chapter 16 on Labour. Provides comprehensive guidance on employment status, remuneration of employees, and the treatment of self-employed and informal workers in national accounts.
3. ¶23 SF-MST, Table 5.3.
4. ¶24 FAO, The State of World Fisheries and Aquaculture 2024. Fish provides over 3.3 billion people with at least 20% of their average animal protein intake.
5. ¶25 Hicks et al. (2019), "Harnessing global fisheries to tackle micronutrient deficiencies." Nature 574: 95-98.
6. ¶26 United Nations, 2030 Agenda for Sustainable Development, SDG Target 2.1.
7. ¶27 SEEA Ecosystem Accounting, Table 6.3.
8. ¶28 SEEA Ecosystem Accounting, para. 2.15. "The benefits to which ecosystem services contribute may be captured in current measures of production (e.g. food, water, energy, recreation) or may be outside such measures (e.g. clean water, clean air, flood protection)."
9. ¶29 United Nations, 2030 Agenda for Sustainable Development, SDG Target 14.b.
0. ¶30 System of National Accounts 2025, guidance on own-account production.
1. ¶31 FAO, Food Security Framework.
2. ¶32 SEEA Ecosystem Accounting (UN et al., 2021; consolidated edition December 2024), Table 6.3. The previously combined "water flow regulation for mitigating river and coastal flooding" service is split into three reference services: Water flow regulation, Flood control, and Storm mitigation. Coastal protection services sit under Flood control services; Storm mitigation services are explicitly confined to storms "other than water-related events". See https://seea.un.org/sites/seea.un.org/files/documents/EA/seea_ea_f124_web_12dec24.pdf (https://seea.un.org/sites/seea.un.org/files/documents/EA/seea_ea_f124_web_12dec24.pdf).
3. ¶33 SEEA Ecosystem Accounting, Chapter 7 (physical supply-and-use tables, SPA/SBA structure) and Chapter 9 §9.3.6 (expected-expenditure / avoided-damage methods) and §9.4 (service-specific valuation). The forward-references in this section to a future Accounting for People Circular (post-September 2026) and the GOAP Social Accounts methodology supplement, rather than replace, SEEA-EA guidance.
4. ¶34 SEEA Ecosystem Accounting, para. 6.51.
5. ¶35 SEEA Ecosystem Accounting, Table 6.3, row 18.
6. ¶36 SEEA Ecosystem Accounting, Table 6.3, entry for "Recreation-related services."
7. ¶37 SEEA Ecosystem Accounting, Table 6.3, row 19.
8. ¶38 SEEA Ecosystem Accounting, Table 6.3, rows 21-22.

DRAFT

9. ¶39 SEEA Ecosystem Accounting, Table 6.3, rows 20, 23.
0. ¶40 TNFD Recommendations, Box 1.
1. ¶41 United Nations, 2030 Agenda for Sustainable Development, SDG Target 14.7.
2. ¶42 SEEA Ecosystem Accounting, para. 1.66. "Measuring the Sustainability of Tourism website…provides guidance on linking ecosystem accounting to measures of tourism activity."
3. ¶43 IPCC, 2022, Annex II: Glossary.
4. ¶44 United Nations, 2030 Agenda for Sustainable Development, SDG Target 14.2.
5. ¶45 United Nations, 2030 Agenda for Sustainable Development, SDG Target 1.5.
6. ¶46 United Nations, Global indicator framework for SDGs, Indicator 1.3.1 measures "Proportion of population covered by social protection floors/systems." SDG 1.3.1 is distinct from the poverty headcount ratio (SDG 1.1.1 / 1.2.1), which measures the prevalence of poverty rather than the institutional coverage of social protection.
7. ¶47 SF-MST, para. 2.6.
8. ¶48 GOAP Social Accounts methodology. The community sense-checking protocol in Section 4.1.1 and Section 4.2 is consistent with the disaggregated-consultation quality assurance approach established in that methodology, which treats disaggregated consultation as a quality assurance requirement rather than a procedural courtesy.
9. ¶49 A future GOAP **Accounting for People Circular** (planned post-September 2026) will provide the consolidated standard for socially-disaggregated indicators of ocean dependency, including community sense-checking protocols. Until then, this Circular records community-identified indicators added through Section 4.2 Step 3 supplementation as candidates for inclusion in that future Circular.
0. ¶50 Ehler, C. and Douvere, F. (2009). *Marine Spatial Planning: a step-by-step approach toward ecosystem-based management.* Intergovernmental Oceanographic Commission and Man and the Biosphere Programme. IOC Manual and Guides No. 53, ICAM Dossier No. 6. UNESCO.
1. ¶51 UNESCO-IOC / European Commission (2021). *MSPglobal International Guide on Marine/Maritime Spatial Planning.* IOC Manuals and Guides No. 89.
2. ¶52 International Finance Corporation (2012). *Performance Standard 5: Land Acquisition and Involuntary Resettlement.* PS5 paragraphs 27 and 28 are referenced in Use Case 7 for particularly-vulnerable identification and livelihood-restoration baselines respectively.
3. ¶53 Equator Principles Association (2020). *The Equator Principles IV.*
4. ¶54 Pacific Islands Forum Fisheries Agency. *Vessel Day Scheme.* See https://www.ffa.int/ (https://www.ffa.int/).
5. ¶55 Parties to the Nauru Agreement (PNA) Office. PNA Office minimum benchmark price for vessel days under the Vessel Day Scheme.
6. ¶56 FAO (2015). *Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication* (the SSF Guidelines), particularly Chapters 5 (Governance of tenure in small-scale fisheries and resource management) and 7 (Value chains, post-harvest and trade).
7. ¶57 Taskforce on Nature-related Financial Disclosures (2023). *Recommendations of the Taskforce on Nature-related Financial Disclosures,* including the LEAP approach (Locate, Evaluate, Assess, Prepare) and the Metrics and Targets pillar.
8. ¶58 International Finance Corporation (2012). *Performance Standard 7: Indigenous Peoples.* Including the Free, Prior and Informed Consent provisions referenced in Use Case 10 and the boundary condition vis-à-vis deferred Use Case 5.

DRAFT

Environmental (including Ecosystem) Goods and Services

Provides guidance on compiling indicators of environmental goods and services, including ecosystem services, within the context of ocean accounting.

Version 0.8.4 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

OUTCOME

This Circular provides guidance on compiling indicators of environmental goods and services, including ecosystem services, within the context of ocean accounting. Ecosystem services represent the contributions that marine and coastal ecosystems make to benefits enjoyed by people and the economy. These contributions fall into three categories: provisioning services such as fish and other harvested biomass, regulating services such as coastal protection and carbon sequestration, and cultural services such as recreation and amenity values.

This Circular establishes an indicator framework aligned with the SEEA Ecosystem Accounting (SEEA EA) reference list of ecosystem services, providing guidance on measurement approaches for provisioning, regulating, and cultural service indicators in both physical and monetary terms. The guidance covers the derivation of indicators from ecosystem service flow accounts, the selection of appropriate measurement units, and the interpretation of physical versus monetary indicators for different policy applications.

Section 3.10 is normative for the publication on monetary valuation method. It sets out the value concepts the accounts use, the SEEA EA five-level preference order, the methods at each level, the methods that are not admissible as account entries, and a worked application across four marine ecosystem services. Compilers valuing any ecosystem service, in any circular, apply that section. Whether and when to value at all, and how the resulting figures should be communicated and caveated, remain with TG-1.9 Safe Usage of Monetary Valuation, which should be read first; asset-level net present value is in TG-3.1 Asset Accounts Sections 3.3 and 3.5.3.

The methodology supports ocean-related EGSS measurement (identifying industries engaged in environmental protection and resource management under CEPA and CReMA), green and blue economy monitoring, environmental protection expenditure tracking, and marine spatial planning by quantifying ecosystem service flows associated with different ocean uses (see TG-1.2 Marine Spatial Planning).

This Circular is distinct from TG-3.2 Flows from Environment to Economy, which covers the underlying supply and use table methodology for ecosystem service accounts. The present Circular focuses on compiling summary indicators from those accounts. It builds on the asset-service linkages established in TG-3.1 Asset Accounts.

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 3
3.1 Ecosystem Services Indicator Framework 4
3.2 Environmental Goods and Services Sector (EGSS) 7
3.3 Provisioning Service Indicators 8
3.4 Regulating Service Indicators 9
3.5 Cultural Service Indicators 12
3.6 Physical vs Monetary Indicators 14
3.7 Compilation Procedure for Ecosystem Service Indicators 15
3.8 Worked Example: Coastal Ecosystem Service Indicators 16
3.9 Summary of Ecosystem Service Measurement Methods 20
3.10 Monetary Valuation Methods 20
4. Acknowledgements 35
5. References 35

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Environmental (including Ecosystem) Goods and Services (2026) (GOAP Technical Guidance on Ocean Accounting, TG-2.4, v0.8.4). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-2/2-4-ecosystem-goods-services/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

1. Outcome

¶1 This Circular provides guidance on compiling indicators of environmental goods and services, including ecosystem services, within the context of ocean accounting. Ecosystem services represent the contributions that marine and coastal ecosystems make to benefits enjoyed by people and the economy. These contributions fall into three categories: provisioning services such as fish and other harvested biomass, regulating services such as coastal protection and carbon sequestration, and cultural services such as recreation and amenity values.[1]

¶2 This Circular establishes an indicator framework aligned with the SEEA Ecosystem Accounting (SEEA EA) reference list of ecosystem services, providing guidance on measurement approaches for provisioning, regulating, and cultural service indicators in both physical and monetary terms.[2] The guidance covers the derivation of indicators from ecosystem service flow accounts, the selection of appropriate measurement units, and the interpretation of physical versus monetary indicators for different policy applications.

¶3 **Section 3.10 is normative for the publication on monetary valuation method.** It sets out the value concepts the accounts use, the SEEA EA five-level preference order, the methods at each level, the methods that are not admissible as account entries, and a worked application across four marine ecosystem services. Compilers valuing any ecosystem service, in any circular, apply that section. Whether and when to value at all, and how the resulting figures should be communicated and caveated, remain with **TG-1.9 Safe Usage of Monetary Valuation**, which should be read first; asset-level net present value is in **TG-3.1 Asset Accounts** Sections 3.3 and 3.5.3.

¶4 The methodology supports ocean-related EGSS measurement (identifying industries engaged in environmental protection and resource management under CEPA and CReMA), green and blue economy monitoring, environmental protection expenditure tracking, and marine spatial planning by quantifying ecosystem service flows associated with different ocean uses (see **TG-1.2 Marine Spatial Planning**).[3]

¶5 This Circular is distinct from **TG-3.2 Flows from Environment to Economy**, which covers the underlying supply and use table methodology for ecosystem service accounts. The present Circular focuses on compiling summary indicators from those accounts. It builds on the asset-service linkages established in **TG-3.1 Asset Accounts**.

DRAFT

2. Requirements

¶1 This Circular requires familiarity with:

- ¶2 **TG-0.1 General Introduction to Ocean Accounts** – for the conceptual framework connecting ecosystems to economic activity
- ¶3 **TG-0.2 Overview of Relevant Statistical Standards** – for the international statistical standards underpinning ocean accounting, including the SEEA EA and SEEA CF frameworks referenced throughout this Circular
- ¶4 **TG-3.1 Asset Accounts** – for understanding ecosystem assets and their relationship to service supply
- ¶5 **TG-3.2 Flows from Environment to Economy** – for the accounting structure underlying ecosystem service indicators, including physical supply and use tables

¶6 For the monetary valuation methods referenced throughout this Circular, see Section 3.10 below and **TG-1.9 Safe Usage of Monetary Valuation**.

3. Guidance Material

¶1 Indicators derived from ecosystem service accounts provide summary measures that can be used to track changes over time, compare across ecosystem types and regions, and inform policy decisions concerning ocean management and conservation. [4]

¶2 This section establishes the indicator framework (Section 3.1), addresses the relationship between ecosystem services and the environmental goods and services sector (Section 3.2), then examines indicators for each major category of ecosystem services: provisioning (Section 3.3), regulating (Section 3.4), and cultural services (Section 3.5). Section 3.6 addresses the distinction between physical and monetary indicators and their appropriate applications. Section 3.7 presents the compilation procedure for deriving indicators from accounts, and Section 3.8 provides a worked example with synthetic data.

3.1 Ecosystem Services Indicator Framework

¶1 The SEEA EA provides a framework for deriving indicators from ecosystem service accounts. [5] Ecosystem service indicators can be derived from both the supply and use perspectives of the ecosystem services supply and use tables (SUTs), and can be expressed in physical or monetary terms. Figure 2.4.1 illustrates how ecosystem assets supply the three service categories, how those flows are recorded in the supply and use tables, and how physical indicators — with an optional valuation step — are derived from them.

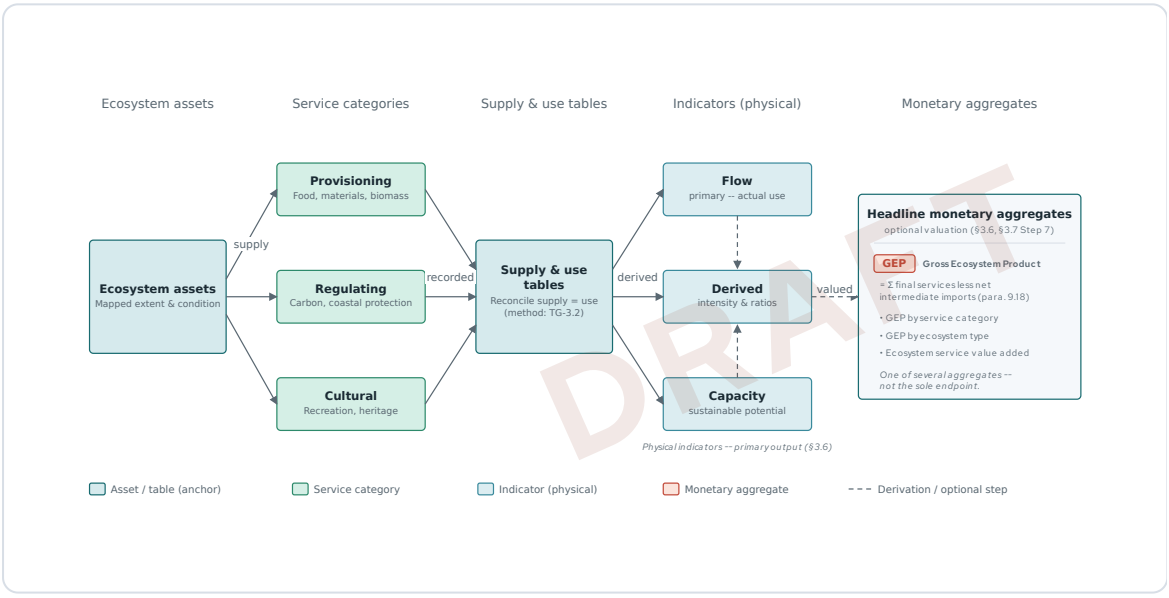


Figure 2.4.1 Ecosystem-service supply and use tables yield physical flow, capacity, and ratio indicators, with optional monetary aggregates. Dashed boxes mark capacity and derived ratios; solid marks primary flow indicators.

Source: TG-2.4 draft v7, §3.1 (indicator typology), §3.6 (physical vs monetary), §3.7 Steps 5--7 (compilation sequence); SEEA EA Tables 5.3--5.4 (supply-use of ecosystem services), Chapter 6 & para. 9.18 (monetary aggregates).

Adapted from: Ouyang et al. (2020), "Using gross ecosystem product (GEP) to value nature in decision making", PNAS 117(25); SEEA EA Figure 6.1 (ecosystem service capacity and flow).

3.1.1 Classification structure

¶1 The reference list of ecosystem services in SEEA EA organises services into three broad categories, summarised in Table 3.1.1 below. [6]

Category	Description
Provisioning services	Ecosystem contributions to the growth of biomass and other materials that are extracted or harvested from ecosystems for use in economic activity.

Category	Description
Regulating and maintenance services	Ecosystem contributions that regulate biological processes and influence climate, hydrological, and biochemical cycles, thereby maintaining environmental conditions beneficial to individuals and society.
Cultural services	The experiential and intangible contributions of ecosystems, related to the perceived or actual qualities of ecosystems, that support a range of cultural benefits.

¶2 For ocean accounting, each category encompasses distinct marine ecosystem services with specific measurement requirements and indicator possibilities. Table 1 summarises the key marine ecosystem services within each category and their indicative measurement units. The selection in Table 1 reflects the ecosystem services most commonly relevant to marine and coastal contexts and is not exhaustive. The SEEA EA reference list (Table 6.3) includes additional services such as wild animals and plants provisioning (covering non-fish marine species and marine bioprospecting for genetic material), storm mitigation services (where these are analytically distinct from coastal protection), and soil and sediment retention services.[7] Compilers should consult the full SEEA EA reference list and include additional services where they are material for their national ocean accounting context.

Service Category	Ecosystem Service	Key Marine Ecosystem Types	Physical Units	Monetary Approach
Provisioning	Fish provisioning	Marine shelf, pelagic, demersal	tonnes biomass	Resource rent
	Aquaculture provisioning	Coastal, marine shelf	tonnes biomass	Residual value
	Seaweed/algae provisioning	Coastal, rocky shores	tonnes biomass	Market prices
	Water supply	Coastal, estuarine	cubic metres	Replacement cost
Regulating	Global climate regulation	Blue carbon ecosystems	tonnes carbon	Carbon prices
	Coastal protection	Coral reefs, mangroves, seagrass	avoided damages	Avoided damage cost
	Water purification	Coastal wetlands, seagrass	volumes filtered	Replacement cost
	Nursery habitat	Mangroves, seagrass, estuaries	hectares habitat	Productivity change
Cultural	Recreation	Coral reefs, beaches, MPAs	visitor-days	Travel cost
	Visual amenity	Coastal seascapes	hedonic index	Hedonic pricing
	Scientific/education	MPAs, research sites	research outputs	Cost-based

¶3 *Table 1: Marine ecosystem services indicator framework (adapted from SEEA EA Table 6.3)*[8]

3.1.2 Indicator types

¶1 Three main types of indicators can be derived from ecosystem service accounts:[9]

¶2 **Flow indicators** measure the quantity of ecosystem services supplied or used during an accounting period. These are the primary indicators derived from ecosystem service SUTs and represent the most direct measure of ecosystem contributions to benefits. Examples include tonnes of fish harvested (provisioning), tonnes of carbon sequestered (regulating), and visitor-days (cultural services).

DRAFT

¶3 **Capacity indicators** measure the potential or sustainable level of ecosystem service supply. The SEEA EA defines ecosystem capacity as "the ability of an ecosystem to generate an ecosystem service under current ecosystem condition, management and uses, at the highest yield or use level that does not negatively affect the future supply of the same or other ecosystem services."[10] Capacity indicators are particularly important for sustainability assessment, as they allow comparison of actual flows against sustainable thresholds. The relationship between ecosystem condition and service capacity is addressed in **TG-3.1 Asset Accounts**.

> *Compiling capacity indicators when formal assessments are unavailable*
> *Formal capacity assessments are available for some marine ecosystem services (notably fisheries stock assessments), but for most regulating and cultural services there is no equivalent assessment in most developing-country contexts. Compilers should adopt a tiered approach:*
> - ¶4 *Tier 1 — Formal assessments. Where stock assessments or capacity models exist (e.g., fisheries B/BMSY data, peer-reviewed coastal protection capacity models), use these directly. For fisheries, FAO (2022) The State of World Fisheries and Aquaculture provides B/BMSY data for global and regional stocks.*[11]
> - ¶5 *Tier 2 — Condition-index proxies. Where no formal capacity assessment exists, derive a proxy using ecosystem condition indices from TG-3.1 Asset Accounts applied to a benchmark service capacity. Document the proxy method and benchmark assumptions transparently.*
> - ¶6 *Tier 3 — Unknown, with documentation. Where no defensible proxy basis exists, leave the capacity entry blank and document the data gap. Blank entries are preferable to uninformed estimates.*
>
> *Sustainability ratios (actual flow / capacity) should only be computed for Tier 1 and Tier 2 entries, with the tier explicitly disclosed in metadata.*

¶7 **Derived indicators** combine ecosystem service data with other information to produce policy-relevant ratios and indices. Examples include ecosystem service intensity indicators (ecosystem services per hectare or per unit of ecosystem asset value), sustainability ratios (actual flow divided by sustainable capacity), and dependency ratios (share of industry output dependent on ecosystem services).

¶8 For practical compilation purposes, compilers may find it useful to distinguish **headline indicators** from **supporting indicators**. Headline indicators are a small number of high-level summary measures intended for national reporting and policy communication—for example, Gross Ecosystem Product, total fish provisioning services, and aggregate coastal protection value. Supporting indicators provide the disaggregated detail needed for analytical work and are typically reported in supplementary tables. The SEEA EA notes that headline indicators "provide a summary of key features of ecosystems that can be monitored over time" whilst detailed indicators "provide more comprehensive information for use by researchers and policy analysts."[12]

3.1.3 Spatial allocation

¶1 Many ecosystem services, particularly regulating services, are generated at landscape or seascape scale involving multiple ecosystem types.[13] For indicator purposes, allocation of service flows to specific ecosystem types may be required. The SEEA EA notes that "a number of ecosystem services, particularly regulating and maintenance services but also some cultural services, are generated at landscape scale in the sense that this involves a range of ecosystem assets of different types."[14]

¶2 For ocean accounting, spatial allocation is particularly relevant for:

DRAFT

- ¶3 Coastal protection services supplied by combinations of coral reefs, mangroves, and seagrass (see **TG-6.1 Coral Reef Accounts**, **TG-6.2 Mangrove and Coastal Wetland Accounting**, and **TG-6.3 Seagrass Accounts**)
- ¶4 Water purification services involving multiple coastal ecosystem types within estuaries
- ¶5 Nursery habitat services that span mangroves, seagrass meadows, and nearshore waters

3.2 Environmental Goods and Services Sector (EGSS)

¶1 The Environmental Goods and Services Sector (EGSS) framework complements the ecosystem services accounting framework by identifying the industries and activities engaged in producing goods and services for environmental protection and resource management purposes.[15] Whilst ecosystem services flow from ecosystems to economic units, EGSS represents the economic response—the industries and activities that produce goods and services aimed at environmental protection (following CEPA) or resource management (following CReMA).

3.2.1 Relationship to ecosystem services

¶1 The SEEA Central Framework describes EGSS as comprising "the producers of environmental protection and resource management goods and services" and notes that "the output of the EGSS equals the sum of the supply of environmental protection services and resource management services."[16] For ocean accounting, the relevant EGSS activities include:

EGSS Category	Ocean-related activities	Related ecosystem services
Environmental protection (CEPA)	Marine pollution monitoring and control (CEPA 1, 2, 3)	Water purification, waste assimilation
	Coastal and marine biodiversity protection (CEPA 6)[17]	Nursery habitat, biodiversity maintenance
	Marine protected area management (CEPA 6, 9)	Multiple regulating and cultural services
Resource management (CReMA)	Protection of biodiversity and landscapes (CEPA 6)[17]	Fish provisioning services
	Coastal forest management (mangroves) (CReMA 11)	Coastal protection, carbon sequestration
	Marine renewable energy production (CReMA 13A)	Energy from renewable sources (abiotic flow)

¶2 *Table 2: Ocean-related EGSS activities and their connections to ecosystem services*

¶3 EGSS output represents economic expenditure on activities that maintain, enhance, or restore the capacity of ecosystems to supply services. For example, expenditure on marine protected area management (CEPA 6) maintains ecosystem condition that sustains the capacity of coral reef, mangrove, and seagrass ecosystems to supply services. Fisheries management expenditure (classified under CEPA 6)[17] aims to maintain fish stocks within sustainable limits, thereby protecting ongoing provisioning capacity.

3.2.2 Compilation approach for ocean EGSS indicators

¶1 EGSS indicators are derived from supply-use tables extended to incorporate environmental protection and resource management activities. The SEEA CF describes the compilation approach as involving three steps: (i) identifying relevant industries and activities using CEPA and CReMA classifications, (ii) measuring the output of environmental goods and services by those industries, and (iii) measuring the use of those goods and services by final demand categories and intermediate consumption.[18]

¶2 For ocean accounting, key data sources include:

DRAFT

- ¶3 **Government budget data** on expenditure by environment and fisheries ministries, classified according to CEPA (e.g., marine protected area management, coastal pollution control) and CReMA (e.g., fisheries stock assessment, aquaculture extension services)
- ¶4 **Industry surveys** of businesses engaged in environmental consulting, marine monitoring, coastal restoration, and other ocean-related environmental services
- ¶5 **Specialised ocean accounts** for fisheries management (**TG-6.7 Fisheries Accounting: Integrating Stock Assessment**), aquaculture (**TG-3.9 Aquaculture Accounts**), and offshore energy (**TG-3.10 Offshore Energy Accounts**) that provide detail on resource management activities

¶6 Compilers should distinguish between the producer types summarised in Table 3.2.2 below.

Producer Type	Description
Primary EGSS producers	Units whose principal activity is environmental protection or resource management (e.g., marine consulting firms, government environmental agencies).
Secondary EGSS producers	Units whose principal activity is not environmental, but which produce environmental goods and services as a secondary output (e.g., aquaculture facilities providing fish nursery habitat management as ancillary environmental activity).
Ancillary EGSS producers	Units producing environmental goods or services as an ancillary activity, that is, as an input to their own principal production activity, not for sale or transfer to other units (e.g., manufacturing plants operating in-house wastewater treatment for coastal discharges, where the treated effluent supports the plant's own production process).

¶7 The distinction matters for indicator interpretation: primary and secondary producers contribute to measured EGSS output and value added, whilst ancillary production is not separately recorded as EGSS output – it is embedded in the intermediate consumption of the producing industry, following SEEA CF paras. 4.100–4.105.[19]

3.3 Provisioning Service Indicators

¶1 Ecosystem service categories and the mapping of marine services to the SEEA EA Table 6.3 framework are described in **TG-3.2 Flows from Environment to Economy** Section 3.1. The sections below present the indicator derivation procedure for each service category applicable to ocean accounting.

3.3.1 Fish provisioning indicators

¶1 Fish provisioning services represent the ecosystem contributions to the growth of wild fish and other aquatic organisms that are harvested by capture fisheries.[20] Key indicators include:

¶2 **Physical flow indicators:**

- ¶3 **Gross catch** (tonnes): The SEEA CF defines gross catch as "the total live weight of fish or other aquatic organisms taken (captured, caught, harvested or removed) for all purposes (commercial, industrial, recreational and subsistence) by all types and classes of fishing units (including fishermen, vessels, gear, etc.) operating in inland, fresh and brackish water areas, and in inshore, offshore and high-seas fishing areas."[21] Gross catch therefore includes retained catch and discarded catch. In practice, NSO compilers should estimate gross catch as landings plus estimated discards, drawing on FAO FishStatJ landings data and FAO/regional fisheries management organisation discard estimates where direct discard surveys are unavailable.[22]
- ¶4 **Landings** (tonnes): Live weight equivalent of fish brought to port, commonly available from fisheries statistics
- ¶5 **Catch by species group** (tonnes): Disaggregated catch data by major species categories (pelagic, demersal, crustaceans, molluscs)

DRAFT

- ¶6 **Catch by ecosystem type** (tonnes): Allocation of catch to supplying marine ecosystem types (e.g., continental shelf, pelagic, coral reef associated)

¶7 **Capacity and sustainability indicators:**

- ¶8 **Sustainable yield** (tonnes): Maximum catch that can be taken without reducing long-term stock productivity
- ¶9 **Exploitation rate**: Ratio of actual catch to sustainable yield, where values above 1.0 indicate depletion
- ¶10 **Stock status index**: Proportion of stocks within biologically sustainable limits

¶11 Fish provisioning services and asset accounts are tightly coupled: extraction recorded in the ecosystem service SUT should correspond to extraction entries in the aquatic resource asset account as described in **TG-3.1 Asset Accounts**.[23] This correspondence provides a consistency check for ocean accounts.

¶12 IUU fishing must be included in provisioning service flow estimates where estimable, because omission overstates sustainability. For the SEEA CF accounting treatment and estimation methods, see **TG-4.10 Extending Fisheries Statistics** Section 3.8.4.

3.3.2 Water and other provisioning indicators

¶1 While provisioning of water from marine sources is typically treated as an abiotic flow rather than an ecosystem service, ecosystem contributions to water quality and regulation may be relevant:[24]

¶2 **Water-related indicators:**

- ¶3 **Freshwater provision from coastal ecosystems** (cubic metres): Where coastal wetlands contribute to freshwater supply
- ¶4 **Desalination intake volume** (cubic metres): Seawater abstraction for desalination (treated as abiotic flow)

¶5 **Other biomass provisioning indicators:**

- ¶6 **Seaweed and algae harvest** (tonnes): Ecosystem contribution to growth of harvested seaweed
- ¶7 **Shellfish harvest** (tonnes): Wild shellfish collection
- ¶8 **Mangrove timber provisioning** (cubic metres): Wood harvested from mangrove ecosystems

3.4 Regulating Service Indicators

> *Decision rule: Intermediate vs final ecosystem services for regulating services used by industries*
> *SEEA EA paras. 6.11–6.17 distinguish **intermediate ecosystem services** (services supplied by one ecosystem to another ecosystem, supporting the supply of a further final service) from **final ecosystem services** (services flowing directly to economic units as beneficiaries).[25] For regulating services consumed by industries (e.g., water purification benefiting an aquaculture operation, coastal protection benefiting tourism infrastructure), the SEEA EA convention is to record them as **final services** flowing to the industry as beneficiary, not as intermediate inputs to the industry's production process. The industry appears as a user column in the ecosystem service use table. Intermediate ecosystem service flows are recorded separately (e.g., in supplementary tables) when the analytical purpose requires tracing the ecosystem-to-ecosystem contributions that support a final service. Compilers should not collapse intermediate and final flows into a single column without indicating which row represents which type, as this conflates analytically distinct relationships and risks double-counting.*

DRAFT

3.4.1 Global climate regulation indicators

¶1 Global climate regulation services represent ecosystem contributions to reducing concentrations of greenhouse gases in the atmosphere through carbon sequestration and storage.[26] Marine ecosystems form part of the global carbon cycle, and "blue carbon" ecosystems such as mangroves, seagrass meadows, and salt marshes are recognised for their climate mitigation potential.

¶2 The SEEA EA identifies two components of global climate regulation services:[27]

¶3 **Carbon retention** reflects the ability of ecosystems to accumulate and retain carbon stocks, supplying a service through the avoided emission of carbon to the atmosphere. The indicator for carbon retention is the stock of carbon held by ecosystem assets at the beginning of the accounting period. Operationally:

> *Carbon Retention Service Flow (period t) = Opening carbon stock (asset account, period t)*

¶4 This identity links the service supply directly to the opening balance of the carbon component of the relevant ecosystem asset account in **TG-3.1 Asset Accounts**. Compilers should record carbon retention service supply values that equal the corresponding opening stock values in the asset account, providing an automatic consistency check. Where formal asset accounts are not yet compiled, the opening stock can be derived from the most recent national blue carbon inventory or default IPCC Wetlands Supplement (2014) values, with documentation of the source.

Service-account row (Table 4-style)	Corresponding TG-3.1 asset-account entry
Carbon retention — mangroves (tC)	Mangrove ecosystem asset: opening C stock
Carbon retention — seagrass (tC)	Seagrass ecosystem asset: opening C stock
Carbon retention — salt marsh (tC)	Salt marsh ecosystem asset: opening C stock
Carbon sequestration — by ecosystem (tC/yr)	Net change in C stock over period (additions less reductions)

DRAFT

¶5 Compilers should distinguish between **soil organic carbon** (slow-cycling, long-residence-time stock dominant in mangrove and seagrass sediments and most relevant to carbon retention indicators) and **above-ground biomass carbon** (faster-cycling, more dynamic, more relevant to short-period sequestration flux estimates). The two pools have different measurement methods and uncertainty profiles, and disaggregation supports interpretation of the retention versus sequestration distinction.

¶6 **Carbon sequestration** reflects the ability of ecosystems to remove carbon from the atmosphere for long-term storage. The indicator is net carbon uptake over the accounting period, typically measured as net ecosystem carbon balance.

¶7 **Key indicators:**

- ¶8 **Carbon stock** (tonnes C): Total carbon stored in blue carbon ecosystems (mangroves, seagrass, salt marshes), including above-ground biomass, below-ground biomass, and soil carbon
- ¶9 **Carbon sequestration rate** (tonnes C/year): Net annual carbon uptake by marine and coastal ecosystems
- ¶10 **Carbon stock by ecosystem type** (tonnes C): Disaggregated carbon storage by ecosystem type (mangroves, seagrass, tidal marshes, marine shelf sediments)
- ¶11 **Carbon retention service** (tonnes C): Opening stock of carbon, serving as proxy for the flow of retention services

¶12 For blue carbon ecosystems, the SEEA EA recommends that measurement scope include carbon stored to a maximum of two metres below the surface in the case of organic carbon-rich soils such as those found in mangroves and seagrass meadows.[28] Related asset information is recorded in **TG-3.1 Asset Accounts**.

¶13 The treatment of global climate regulation services raises questions about user attribution. The SEEA EA notes that the user of global climate regulation services is "the global community or, where the focus is on a national ecosystem accounting area, the rest of the world."[29] For national ocean accounts, this implies that the bulk of carbon sequestration services should be attributed to the rest of the world as the beneficiary. This attribution reflects the global public good nature of climate regulation, whilst a country may also derive domestic benefits from its own contribution to global climate stability. In practice, compilers should record the full physical flow of carbon sequestration in the supply table (attributed to domestic ecosystem types) and allocate the use to "rest of the world" in the use table. For monetary valuation, the exchange value approach would value the service at the price that would be agreed between a willing buyer and seller, which in practice is typically approximated using observed carbon market prices or abatement cost methods. The indicator implications are that physical indicators of carbon sequestration represent domestic ecosystem contributions, whilst monetary indicators should be interpreted carefully given that the beneficiaries are predominantly global rather than domestic.

3.4.2 Coastal protection indicators

¶1 For the full biophysical basis of coastal protection services, SPA/SBA delineation, and tiered method selection, see **TG-3.2 Flows from Environment to Economy** Section 3.3.[30], [31]

> *Operational definition: "kilometres of coastline protected"*
> *"Kilometres of coastline protected" is defined as* ***the length of beneficiary shoreline landward of protective ecosystems with population or assets at risk under a defined reference hazard scenario****, following SEEA EA para. 9.72 (no flow recorded where there are no potential damages to avoid).*[32] *Compilers must:*
>
> 1. ¶2 ***Choose the hazard reference scenario*** *using the nationally adopted return period for coastal flood and storm risk assessment (commonly 1-in-50 or 1-in-100 year for coastal engineering applications). The choice must be documented in compilation metadata and held constant across reporting periods.*
> 2. ¶3 ***Choose the attenuation threshold*** *(the minimum wave-energy or wave-height reduction required for a shoreline segment to qualify as "protected") drawing on national coastal risk assessments, InVEST coastal vulnerability or coastal protection model parameters, or peer-reviewed studies appropriate to the ecosystem types present (e.g., Beck et al. 2018 for coral reefs).*[33]
> 3. ¶4 ***Apply a tiered approach*** *where data are limited:*
>   - ¶5 *Tier 1. Modelled beneficiary shoreline with explicit attenuation and exposure analysis.*
>   - ¶6 *Tier 2. Kilometres of protective ecosystem frontage multiplied by an effectiveness factor derived from peer-reviewed or national-standard sources.*
>   - ¶7 *Tier 3. Kilometres of protective ecosystem frontage as a minimum proxy, flagged as an unadjusted upper bound.*
>
> *SEEA EA does not prescribe a single numeric attenuation threshold or return period for coastal protection service measurement. Both are localisation decisions to be made by the compiling agency drawing on national coastal risk assessment standards. Cross-country comparability requires that the chosen return period and attenuation threshold are disclosed in compilation metadata and held constant across reporting periods. Cross-references: TG-6.1 Coral Reef Accounts, TG-6.2 Mangrove and Coastal Wetland Accounting.*

¶8 **Physical indicators:**

DRAFT

- ¶9 **Coastline protected** (kilometres): Length of beneficiary coastline as defined in the operational definition box above
- ¶10 **Area protected** (hectares): Coastal land area with reduced flood risk due to ecosystem services
- ¶11 **Wave attenuation** (%): Percentage reduction in wave energy provided by coral reefs, mangroves, or seagrass
- ¶12 **Population protected** (number): Coastal population within areas benefiting from ecosystem-based protection

¶13 **Capacity indicators:**

- ¶14 **Protection capacity index**: Measure of ecosystem condition relative to optimal protective function
- ¶15 **Vulnerability reduction**: Change in coastal vulnerability attributable to ecosystem services

¶16 The measurement of coastal protection services depends on the likelihood of hazard events and the presence of assets or population at risk.[32] Even where hazard probability is high, no ecosystem service flow is recorded if there are no potential damages to be avoided.

3.4.3 Other regulating service indicators

¶1 **Water purification indicators:**

- ¶2 **Nutrient retention** (tonnes N, P): Quantity of nutrients removed or retained by coastal ecosystems
- ¶3 **Sediment retention** (tonnes): Sediment captured by coastal vegetation before reaching marine waters
- ¶4 **Water quality improvement index**: Composite measure of ecosystem contribution to water quality

¶5 **Nursery and habitat maintenance indicators:**

- ¶6 **Nursery habitat extent** (hectares): Area of mangroves, seagrass, and other ecosystems providing nursery functions
- ¶7 **Recruitment contribution** (%): Estimated proportion of commercial fish recruitment dependent on coastal nursery habitat
- ¶8 **Habitat connectivity index**: Measure of connectivity among nursery, juvenile, and adult habitats

¶9 The SEEA EA treats nursery services as potentially intermediate services: "the nursery population services supplied by seagrass meadows are an input to the supply of fish biomass provisioning services, which in turn contribute to the benefit of marketed fish."[34] Recording both final and intermediate ecosystem services is therefore necessary to fully capture the contributions of coastal ecosystems to commercial fisheries.

¶10 **Erosion control indicators:**

- ¶11 **Sediment stabilisation** (hectares): Coastal area with reduced erosion due to ecosystem services
- ¶12 **Erosion rate reduction** (%): Percentage reduction in erosion attributable to vegetation

3.5 Cultural Service Indicators

3.5.1 Recreation indicators

¶1 Recreation-related services are the ecosystem contributions to recreational activities through the biophysical characteristics and qualities of ecosystems that enable people to use and enjoy the marine environment.[35]

DRAFT

¶2 **Physical indicators:**

- ¶3 **Visitor-days** (number): Total person-days of recreational visits to marine and coastal ecosystems
- ¶4 **Recreational fishing trips** (number): Fishing trips undertaken for recreation rather than commercial purposes
- ¶5 **Diving/snorkelling visits** (number): Visits to coral reefs and other underwater attractions
- ¶6 **Beach visits** (number): Recreational visits to coastal beaches and shores

¶7 **Activity-specific indicators:**

- ¶8 **Recreational catch** (tonnes): Fish caught during recreational fishing activities (also recorded as a separate row in the provisioning service supply and use tables — see decision rule below)
- ¶9 **Whale/dolphin watching trips** (number): Marine wildlife tourism activities
- ¶10 **Marine protected area visits** (number): Recreational visits to MPAs

> *Decision rule: Recording recreational catch in supply and use tables* [36]
> *Where recreational catch is* ***material*** *(as a rule of thumb, where it represents 5% or more of commercial catch by weight, or where it is policy-relevant regardless of share), compilers should record it as a* ***dedicated row*** *in the physical supply and use tables for fish provisioning, with users allocated to "Households" (subsistence/recreational consumption) or "Tourism" (where the catch supports a tourism enterprise). The recreation cultural service is recorded separately on its visitor-day row. The two rows capture distinct phenomena — biomass extracted vs. experiential service — and must not be aggregated into a single headline "fish provisioning" figure without disclosure. Where recreational catch is* ***not material*** *and is omitted from the supply table, compilers should add a footnote to the provisioning row explicitly stating the omission and the rationale.*

¶11 In practice, the physical indicator for the cultural service should be expressed in units that capture the recreational experience (visitor-days or trips), whilst the physical indicator for the provisioning service should be expressed in harvest units (tonnes). Monetary indicators require particular attention: the cultural service value (willingness to pay for the recreational experience) and the provisioning service value (resource rent on the harvested biomass) capture distinct economic contributions and should be presented separately rather than summed without explanation.

3.5.2 Amenity indicators

¶1 Visual amenity services represent ecosystem contributions to local living conditions through sensory benefits, especially visual appreciation of seascapes. [37]

¶2 **Physical indicators:**

- ¶3 **Coastal access points** (number per km of coastline): Publicly accessible coastal entry points enabling visual and sensory access to seascapes
- ¶4 **Seascape quality index**: Composite measure of visual amenity characteristics
- ¶5 **Blue space accessibility** (population within distance): Population with access to coastal recreational areas

¶6 **Monetary indicators (see Section 3.6.2):**

- ¶7 **Coastal property premium index**: Hedonic-pricing-derived measure of property value differentials attributable to marine views and coastal proximity. This is a monetary-economic indicator (not a physical indicator) and is compiled using hedonic pricing methods. See Section 3.10.3 below for the hedonic pricing method and its place in the preference order.

3.5.3 Spiritual, scientific, and educational indicators

¶1 **Scientific and educational indicators:**

- ¶2 **Research publications** (number): Scientific outputs associated with marine ecosystem research
- ¶3 **Educational visits** (number): School and university visits to marine educational sites
- ¶4 **Traditional knowledge documentation**: Records of indigenous and local knowledge associated with marine ecosystems

¶5 **Spiritual and symbolic indicators:**

- ¶6 **Sacred site extent** (hectares): Marine and coastal areas of spiritual significance
- ¶7 **Cultural heritage sites** (number): Marine and coastal sites of cultural and historical significance

¶8 Indigenous and local communities often hold deep cultural and spiritual connections to marine ecosystems that conventional indicators may not adequately capture. The governing principle is that measurement of these values rests on the free, prior, and informed consent (FPIC) of the communities concerned: indicators are co-designed with those communities, complex cultural relationships are not reduced to simplistic quantitative measures, and qualitative supplementary information accompanies any quantitative figures. Where traditional ecological knowledge contributes to the understanding of ecosystem condition or service flows, compilers should acknowledge and appropriately attribute it. [38]

3.6 Physical vs Monetary Indicators

¶1 The trade-offs between physical and monetary ecosystem service indicators — including advantages, limitations, and appropriate applications — are analysed in **TG-1.9 Safe Usage of Monetary Valuation**, which should be read in conjunction with this circular. The methods themselves, and the preference order governing their selection, are set out in Section 3.10 below. [39] Physical accounts should always be compiled as the primary output, with monetary valuation undertaken as a complement where appropriate and feasible. [40]

3.6.1 Valuation approaches by service type

¶1 Valuation approach selection by service type follows the criteria in Table 1. [41] For global climate regulation services, the preferred valuation approach uses observed carbon market prices or abatement cost methods, which align with the exchange value concept used in national accounts. The "social cost of carbon" (SCC) estimates the marginal damage from an additional tonne of carbon emissions. It represents a welfare-based measure rather than an exchange value and is therefore not the preferred approach under SEEA EA guidance. [42] Where carbon market prices are unavailable, or where the policy context specifically requires a damage-cost perspective, the SCC may be used as an alternative. Where the SCC is used, compilers should clearly document that it represents a welfare value rather than an exchange value and note the divergence from standard accounting practice.

3.6.2 Presentation and interpretation

¶1 When presenting ecosystem service indicators, compilers should follow the principles set out in Table 3.6.4 below. [43]

Principle	Description
Present physical and monetary indicators together	Physical accounts provide the foundation and should always accompany monetary values.
Document methods and assumptions	Clearly state the valuation methods used and key assumptions.
Acknowledge uncertainties	Communicate the confidence level and key sources of uncertainty.

DRAFT

Principle	Description
Avoid over-interpretation	Monetary values represent exchange values, not the full importance of ecosystems.
Provide contextual information	Include data on ecosystem extent, condition, and trends to support interpretation.

3.7 Compilation Procedure for Ecosystem Service Indicators

Step 1: Identify priority ecosystem services and users

¶1 Identify which ecosystem services are most relevant to the national or subnational ocean accounting area, and which economic units and communities use those services. This step should involve:

- ¶2 Reviewing the SEEA EA reference list (Table 6.3) and selecting services relevant to the ecosystem types present (see **TG-3.2 Flows from Environment to Economy**, Table 1a for marine ecosystem services by type)
- ¶3 Consulting with policy users to identify which services are priorities for management and monitoring [44]
- ¶4 Mapping ecosystem service users by institutional sector (industries, households, government, rest of world)

¶5 For ocean accounting, priority services typically include fish provisioning (used by fisheries industries), coastal protection (used by coastal property owners and government), carbon sequestration (used by the global community), and recreation (used by households).

Step 2: Assemble data sources

¶1 Primary data sources include:

- ¶2 **Fisheries statistics** from national fisheries agencies and FAO FishStatJ, providing catch data by species, gear type, and fishing zone
- ¶3 **Ecological monitoring data** from field surveys measuring carbon stocks, water quality, and condition variables (see **TG-4.2 Survey Methods**)
- ¶4 **Remote sensing data** for extent and condition of blue carbon ecosystems (see **TG-4.1 Remote Sensing Data**)
- ¶5 **Tourism statistics** from visitor surveys at marine protected areas, coastal recreation sites, and diving operators
- ¶6 **Geospatial data** on coastal population and assets at risk from flooding and erosion

¶7 Data quality should be assessed following **TG-0.7 Quality Assurance**, with particular attention to temporal consistency and spatial coverage.

Steps 3–4: Compile the physical supply and use tables

¶1 The supply and use tables are the input to every indicator below, and their compilation is specified in **TG-3.2 Flows from Environment to Economy** Section 3.3 — the structure of PSUTs, the procedure, the supply and use sub-procedures, physical units, the supply = use identity, and the treatment of beneficiaries who fall outside survey frames. It is not restated here.

¶2 Two properties of the compiled tables determine what the indicators in Step 5 can carry, and are worth confirming before proceeding:

- ¶3 **Supply is attributed by ecosystem type.** Without that attribution the disaggregated and intensity indicators below cannot be produced, only the headline totals.
- ¶4 **The supply = use identity holds for every service.** An indicator derived from tables that do not balance will not reconcile with any other national figure, and the imbalance usually means a

DRAFT

beneficiary group is missing rather than that a number is wrong.

Step 5: Derive physical flow indicators

¶1 From the compiled supply and use tables, derive flow indicators for reporting and analysis:

- ¶2 **Headline flow indicators**: Total supply of each priority service, aggregated across all ecosystem types
- ¶3 **Disaggregated flow indicators**: Supply by ecosystem type, use by sector
- ¶4 **Intensity indicators**: Flow per hectare of ecosystem extent (requires linking to extent accounts from **TG-3.1 Asset Accounts**)
- ¶5 **Sustainability indicators**: Actual flow compared to capacity or sustainable yield

Step 6: Apply monetary valuation (optional)

¶1 Where monetary indicators are required, apply valuation methods following the preference order in Section 3.10.2 below:

- ¶2 For services with observable market prices (e.g., fish quota values, carbon credits), apply observed prices
- ¶3 For services embedded in market transactions (e.g., fish provisioning), apply resource rent method
- ¶4 For services without markets (e.g., coastal protection, water purification), apply replacement cost or avoided damage cost methods
- ¶5 For recreation, apply travel cost or consumer expenditure methods

¶6 For each valuation, document the method, data sources, key assumptions, and uncertainty.

Step 7: Calculate aggregate monetary indicators

¶1 From the monetary valuations, derive aggregate indicators:

- ¶2 **Gross Ecosystem Product (GEP)**: Sum of monetary values of all final ecosystem services, less net imports of intermediate ecosystem services from outside the accounting area (SEEA EA para. 9.18). In practice the deduction is often zero where the accounting area is hydrologically and ecologically self-contained, but compilers must explicitly check for cross-boundary intermediate service flows — for example, freshwater purification capacity supplied by inland watersheds to coastal estuaries — and deduct the net import where material. Where the deduction is assumed zero, this assumption must be stated in metadata.
- ¶3 **GEP by service category**: Provisioning, regulating, cultural
- ¶4 **GEP by ecosystem type**: Marine shelf, pelagic, coastal wetlands, etc.
- ¶5 **Ecosystem service value added**: GEP attributed to domestic ecosystem assets (excluding imports of services)

Step 8: Integration with other accounts and policy applications

- ¶1 **Cross-check with asset accounts**: Ensure that extraction flows (e.g., fish harvest) recorded in service accounts match extraction entries in asset accounts
- ¶2 **Link to EGSS accounts**: Compare ecosystem service values with expenditure on environmental protection and resource management
- ¶3 **Support SDG 14 monitoring**: Derive indicators for SDG 14.4.1 (proportion of fish stocks within sustainable limits), 14.5.1 (marine protected area coverage, linked to service supply), and 14.7.1 (economic benefits from sustainable ocean resources)
- ¶4 **Inform budget processes**: Provide evidence for natural capital budgeting (see **TG-1.1 National Ocean Budgets**)

3.8 Worked Example: Coastal Ecosystem Service Indicators

DRAFT

¶1 The example uses synthetic data for three marine ecosystem types (mangroves, seagrass meadows, and coral reefs) to illustrate the compilation procedure described in Section 3.7. The supply = use identity (total supply in Table 4 equals total use in Table 5 for each service row) is verified at Step 4 below. Compilers revising either table independently must re-verify this identity.

Scenario description

¶1 The accounting area is a coastal province encompassing 500 km² of mangrove forest, 200 km² of seagrass meadows, and 150 km² of coral reef systems. The area supports commercial fisheries, coastal aquaculture, and marine tourism. The accounting period is calendar year 2025.

Step 1-2: Priority services and data sources

¶1 Through consultation with the provincial environment ministry and fisheries agency, five priority ecosystem services were identified:

Ecosystem Service	Data Source	Measurement Unit
Fish provisioning	Fisheries agency catch statistics	tonnes (live weight)
Coastal protection	Coastal engineering study + population census	kilometres beneficiary coastline (see Section 3.4.2 operational definition)
Carbon sequestration	Field survey + remote sensing	tonnes C/year
Water purification	Estuary water quality monitoring + nutrient budget model	tonnes N removed/year
Recreation	Marine park visitor survey	visitor-days/year

Steps 3–4: The compiled supply and use tables

¶1 The tables below are the **input** to this example, compiled under **TG-3.2 Flows from Environment to Economy** Section 3.3 from field surveys, remote sensing, modelling, fisheries registration data, the property cadastre and tourism statistics. They are reproduced here because the indicator arithmetic that follows cannot be checked without them, not to restate how they were built.

DRAFT

Service	Mangroves	Seagrass	Coral Reef	Total Supply
Fish provisioning — commercial (tonnes)	1,200	800	1,500	3,500
Fish provisioning — recreational (tonnes)	20	10	70	100
Coastal protection (km beneficiary coastline)	45	30	25	100
Carbon sequestration (tC/yr)	4,000	1,600	150	5,750
Water purification (tN/yr)	120	80	0	200
Recreation (visitor-days)	5,000	2,000	45,000	52,000

¶2 *Table 4: Physical ecosystem service supply by ecosystem type, 2025. Supply totals in this table must equal use totals in Table 5 for each row; the identity is verified at Step 4.*

¶3 **Reading the supply table**: coral reefs dominate commercial fish provisioning (1,500 t, 43%) and recreation (45,000 visitor-days, 87%); mangroves dominate carbon sequestration (4,000 tC/yr, ~70%) and coastal protection (45 km, 45%). These shares drive the disaggregated indicators at Step 5.

Service	Fisheries Industry	Aquaculture	Tourism	Coastal Households	Rest of World	Total Use
Fish provisioning — commercial (tonnes)	2,800	0	0	0	0	2,800

Service	Fisheries Industry	Aquaculture	Tourism	Coastal Households	Rest of World	Total Use
Wild seed extraction to aquaculture (tonnes) [intermediate flow to asset account]	0	700	0	0	0	700
Fish provisioning — recreational (tonnes)	0	0	30	70	0	100
Coastal protection (km beneficiary coastline)	0	20	0	80	0	100
Carbon sequestration (tC/yr)	0	0	0	0	5,750	5,750
Water purification — final regulating service to aquaculture industry (tN/yr)	0	150	0	0	0	150
Water purification — final regulating service to households (tN/yr)	0	0	0	50	0	50
Recreation (visitor-days)	0	0	8,000	44,000	0	52,000

¶4 *Table 5: Physical ecosystem service use by sector, 2025. Supply = use identity verified for all rows against Table 4 (commercial fish provisioning 2,800 + wild seed extraction 700 = 3,500; water purification 150 + 50 = 200; all other rows match by construction).*

¶5 **Reading the use table**: the supply = use identity holds for every row (commercial fish provisioning 2,800 + wild seed extraction 700 = 3,500; water purification 150 + 50 = 200). Carbon sequestration is attributed entirely to the rest of the world, reflecting its global public-good character. It still counts in GEP at Step 7, because it is supplied by ecosystems within the accounting area; its monetary value should be read with that user attribution in mind. Households take 80% of coastal protection and 85% of recreation, the two shares the dependency indicators in **TG-2.3** read.

Step 5: Physical flow indicators

¶1 From the supply and use tables, headline and derived indicators were calculated:

¶2 **Headline flow indicators:**

- ¶3 Total commercial fish provisioning: 3,500 tonnes
- ¶4 Total recreational fish provisioning: 100 tonnes
- ¶5 Total coastal protection: 100 km beneficiary coastline
- ¶6 Total carbon sequestration: 5,750 tC/yr
- ¶7 Total water purification: 200 tN/yr
- ¶8 Total recreation: 52,000 visitor-days

¶9 **Intensity indicator matrix (per km² of ecosystem extent):**

Service	Mangroves (500 km²)	Seagrass (200 km²)	Coral Reef (150 km²)
Fish provisioning — commercial (t/km²)	2.4	4.0	10.0
Carbon sequestration (tC/yr/km²)	8.0	8.0	1.0
Coastal protection — linear (m coastline/km² of ecosystem area)[45]	90	150	— (see note)
Recreation (visitor-days/km²)	10	10	300

¶10 *Table 5a: Intensity indicators by ecosystem type and service, 2025.*

¶11 Notes on omitted/qualified cells:

DRAFT

- ¶12 **Coral reef coastal protection** is omitted from the linear-per-area row above because coral reef coastal protection in this example is more meaningfully expressed per kilometre of reef frontage facing the coast (a linear-on-linear metric) than per km² of reef area. Reporting an areal denominator would be misleading where the reef's protective function is determined by frontage geometry rather than total area.
- ¶13 **Water purification and recreational fish provisioning intensities** are not reported on a per-km² basis in this example because the supply attributions are dominated by a single ecosystem type for water purification (mangroves and seagrass only) and are small in absolute terms for recreational catch. Compilers facing different attributions should compute these intensities.

¶14 **Derived dependency indicators:**

- ¶15 Fisheries industry dependency on ecosystem services: 2,800 tonnes commercial fish harvest (80% of commercial provisioning supply attributed to the fisheries industry)
- ¶16 Aquaculture dependency: 700 tonnes wild seed extraction + 150 tN water purification (final regulating service)
- ¶17 Coastal household dependency: 80 km coastal protection + 50 tN water quality maintenance + 44,000 recreation visitor-days + 70 tonnes recreational catch

Step 6-7: Monetary indicators (illustrative)

¶1 For demonstration purposes, monetary values were estimated using the following approaches (see **TG-1.9 Safe Usage of Monetary Valuation** for method details):

Service	Physical Flow	Unit Value	Valuation Method	Monetary Value
Fish provisioning (commercial; wild seed is an intermediate flow and is excluded)	2,800 tonnes	USD 600/tonne	Resource rent	USD 1,680,000
Coastal protection	100 km	USD 500,000/km	Avoided damage cost	USD 50,000,000
Carbon sequestration	5,750 tC/yr	USD 50/tC	Carbon market price	USD 287,500
Water purification	200 tN/yr	USD 8,000/tN	Replacement cost	USD 1,600,000
Recreation	52,000 v-days	USD 25/v-day	Consumer expenditure	USD 1,300,000
Total (GEP, before net-import deduction)				**USD 54,867,500**

DRAFT

¶2 *Table 6: Monetary ecosystem service account, 2025. The GEP figure above is the sum of final ecosystem service values supplied by ecosystems within the accounting area. In this worked example, no imports of intermediate ecosystem services from outside the accounting area are assumed (the coastal province's water purification supply does not draw on inland watershed services for the modelled period). In practice, compilers must check for cross-boundary intermediate service flows — e.g., freshwater services from inland watersheds supporting coastal estuarine water purification — and deduct net imports per SEEA EA para. 9.18 to obtain the SEEA-EA-compliant GEP. See Step 7.*

¶3 **Interpretation**: The Gross Ecosystem Product (GEP) for the coastal province is approximately USD 54.9 million in 2025 (no intermediate-service net-import deduction applied — see Table 6 note), with coastal protection representing 91% of the total monetary value. This reflects the avoided damage approach, which captures the high value of infrastructure and population at risk in the densely populated coastal zone. Fish provisioning (USD 1.7 million) represents the resource rent accruing to the ecosystem (distinct from the gross value of fish landings, which includes labour and capital inputs). Carbon sequestration has relatively low monetary value (USD 287,500) due to low

carbon prices, though the physical quantity (5,750 tC/yr) is substantial. Recreation services (USD 1.3 million) reflect consumer expenditure on marine-based tourism.

Step 8: Policy applications

¶1 The compiled indicators supported several policy applications:

¶2 **Natural capital budgeting**: The provincial government incorporated the GEP estimate (USD 54.9 million) into supplementary budget documents, comparing ecosystem service values with the provincial environment budget (USD 3.2 million), yielding a 17:1 ratio of ecosystem service value to conservation expenditure. This ratio does not represent a benefit-cost analysis, as ecosystem services are sustained by factors beyond government expenditure alone.

¶3 **SDG 14 monitoring**: The fish provisioning indicator (3,500 tonnes commercial harvest) was compared to the sustainable yield estimate (3,200 tonnes from stock assessment). The resulting exploitation rate of 1.09 (9% overfishing) was reported under SDG 14.4.1.

¶4 **Marine spatial planning**: The ecosystem service supply data by ecosystem type were used to evaluate alternative coastal development scenarios, quantifying the trade-offs between converting mangrove areas to aquaculture (loss of carbon sequestration and coastal protection) versus maintaining natural ecosystems.

¶5 **EGSS compilation**: Government expenditure on marine protected area management (CEPA 6), fisheries monitoring (CEPA 6), and mangrove restoration (CEPA 4, CReMA 11) totaling USD 3.2 million was classified as ocean-related EGSS output, enabling comparison with the ecosystem service flows those expenditures aim to maintain. Government fisheries-management expenditure was classified under CEPA 6 in accordance with the Eurostat EGSS reclassification of former CReMA 12 activities (see Table 2 footnote).

3.9 Summary of Ecosystem Service Measurement Methods

¶1 Sections 3.3–3.5 present the full compilation guidance for provisioning, regulating, and cultural services indicators respectively. For a cross-cutting comparison of data requirements and feasibility, see Table 1.

DRAFT

3.10 Monetary Valuation Methods

¶1 Where monetary valuation is undertaken, this section is normative for the choice of method. **TG-1.9 Safe Usage of Monetary Valuation** remains the guidance on *whether and when* to value at all, and on how the resulting figures should be communicated; it should be read first. This section sets out *how*: the value concepts the accounts use, the SEEA EA preference order, the methods at each level, the methods that are not admissible in accounts, and a worked application across four marine ecosystem services.

¶2 Asset-level valuation — the net present value of ecosystem service flows, the discount rate, the horizon, and the treatment of degradation and enhancement — is set out in **TG-3.1 Asset Accounts** Sections 3.3 and 3.5.3, which applies the preference order below to the service flows it discounts.

3.10.1 Valuation in the SEEA framework

Exchange values versus welfare values

¶1 A key characteristic of ecosystem accounts is that they use exchange values, defined as "the values at which goods, services, labour or assets are in fact exchanged or else could be exchanged for cash."[46] For the vast majority of entries in national accounts, exchange values are measured using data from observed transactions involving market prices. Market prices are amounts of money that willing buyers pay to acquire something from willing sellers.[47]

¶2 Exchange values differ from welfare values, which are commonly used in environmental cost-benefit analysis and include consumer surplus.[48] Consumer surplus is the difference between what

is paid for a good or service and what a person is willing to pay. The accounts record the former (exchange value), not the latter (total willingness to pay including surplus). [49]

¶3 This distinction has important implications for ocean accounting:

Concept	Exchange Values	Welfare Values
Definition	Values at which items are or could be exchanged for cash	Total benefit including consumer/producer surplus
Primary Use	National accounts, balance sheets, GDP	Cost-benefit analysis, impact assessment
Includes Surplus	No	Yes
Basis	Observed or imputed transactions	Willingness to pay/accept
Aggregation	Directly comparable with economic aggregates	Not comparable with national accounts

¶4 The SNA 2025 clarifies that the integrated framework does not attempt to determine the utility of flows and stocks within its scope. Rather, it measures the current exchange value of entries in the accounts in monetary terms. [50] Exchange values align with national accounting conventions and are the appropriate concept for entries in ecosystem accounts. Welfare values remain important for cost-benefit analysis, but they yield estimates that cannot be directly compared with GDP, national wealth, or other aggregates from the System of National Accounts. Practitioners should use this distinction as a first check when selecting or interpreting valuation studies for ocean accounting purposes.

The SNA production boundary

¶5 Ecosystem services as defined in SEEA EA fall outside the production boundary of the SNA. The SEEA EA extends this boundary by recording flows of ecosystem services. [51] This extension creates a framework where:

- ¶6 **Provisioning services** (e.g., wild fish harvest, aquaculture inputs, coastal timber) contribute to SNA benefits: goods and services already within the SNA production boundary
- ¶7 **Regulating services** (e.g., coastal protection, carbon sequestration, water purification) typically contribute to non-SNA benefits that are outside the production boundary
- ¶8 **Cultural services** (e.g., marine recreation, coastal amenity) may contribute to both SNA and non-SNA benefits depending on institutional arrangements [52]

¶9 For ocean accounting, this means that the value of many marine ecosystem services, such as coastal protection, carbon sequestration, and recreation, requires estimation using non-market valuation methods since direct market transactions are rarely observed.

¶10 **Classifying cultural services as SNA or non-SNA benefits:** Because the boundary for cultural services depends on national institutional arrangements, compilers should apply the following three-question checklist before classifying a specific cultural service (e.g., marine recreation by residents): [53]

1. ¶11 Is a monetary transaction for this service already recorded in national accounts (e.g., tourism receipts, recreation-sector output)?
2. ¶12 Is the economic unit receiving the service a market producer whose output enters GDP?
3. ¶13 Is the benefit already captured in existing GDP aggregates through the expenditure or production approach?

¶14 If the answer to any question is yes, treat the service as contributing to SNA benefits. If the answer to all three questions is no, treat it as contributing to non-SNA benefits. This applies at the level of each specific service flow and beneficiary group. The same marine ecosystem may supply both SNA and non-SNA cultural services to different beneficiaries. See SEEA EA paras. 5.25–5.28 for classification of ecosystem service beneficiaries.

DRAFT

Status of the SEEA EA valuation chapters

¶15 The specific status of different components of SEEA EA affects the authority the valuation guidance below can carry.

¶16 The United Nations Statistical Commission at its fifty-second session in March 2021 (Decision 52/101):

- ¶17 **Adopted** SEEA EA chapters 1-7 (accounting framework and physical accounts) as an **international statistical standard**
- ¶18 **Recognized** that chapters 8-11 describe **"internationally recognized statistical principles and recommendations"** for valuation of ecosystem services and assets in a context coherent with the SNA for countries undertaking valuation
- ¶19 **Noted** chapters 12-14 as describing applications and extensions [54]

¶20 **Implication for Ocean Accounting:** The physical accounting framework has full international statistical standard status. The valuation guidance represents best practice recommendations that countries may apply when undertaking valuation, rather than mandatory requirements. This circular follows these recommendations whilst acknowledging their status.

¶21 The characterisation above is drawn directly from the text of UNSC Decision 52/101. The Commission's choice of the phrase "internationally recognized statistical principles and recommendations" rather than "international statistical standard" for chapters 8-11 was deliberate. At the time of adoption, monetary valuation methods had not reached the same level of methodological maturity as the physical accounting framework in chapters 1-7. In practical terms, this means that countries are encouraged but not required to implement monetary valuation, and where they do so they should follow the principles and recommendations set out in those chapters. Circulars carrying the **Core** badge draw only on adopted standards, so valuation guidance is presented throughout the Technical Guidance as authoritative best practice rather than as binding statistical standard.

¶22 The System of National Accounts 2025 (SNA 2025) was adopted by the United Nations Statistical Commission at its fifty-fifth session in 2024 as the updated international statistical standard for national accounts, replacing SNA 2008. The SEEA EA 2021 valuation recommendations remain the operative guidance for ecosystem accounting pending any future revision of SEEA EA, and SNA 2025 does not amend the SEEA EA valuation chapters. Where this circular cites both SNA 2008 and SNA 2025 paragraph numbers, the SNA 2025 reference is authoritative for current practice. [55]

DRAFT

3.10.2 Valuation method preference order

¶1 The SEEA EA establishes a preference order for valuation methods based on their proximity to observed market prices and their alignment with exchange value concepts. [56]

Five-level preference hierarchy

¶2 Table 3.10.1 summarises the SEEA EA preference order with examples relevant to ocean accounting.

¶3 *Table 3.10.1: SEEA EA valuation method preference order*

Preference level	Description	Ocean accounting examples
1. Directly observable prices	Prices observed in actual market transactions for the ecosystem service or asset	Fish quota (ITQ) trading prices; carbon credit prices from verified offset markets; water abstraction rights; aquaculture site lease fees
2. Prices from markets for similar goods/services	Prices observed in markets for goods/services sufficiently similar to the one being valued	Prices from comparable fisheries in other jurisdictions; rental values from comparable coastal sites; timber prices from comparable mangrove forests

Preference level	Description	Ocean accounting examples
3. Prices embodied in market transactions	Values estimated from market transactions where the ecosystem contribution is embedded	Resource rent from fisheries (gross output minus all non-ecosystem inputs); hedonic property prices reflecting coastal amenity; productivity change method for nursery services
4. Prices based on revealed expenditures (costs)	Values estimated from actual expenditures on related goods/services that have already been made	Averting behaviour (defensive expenditure actually incurred); travel expenditure (consumer expenditure method)
5. Prices based on expected expenditures or markets	Values estimated from modelled or hypothetical expenditures	Replacement cost (where the replacement has not actually been built); simulated market prices; avoided damage cost estimates based on modelled flood scenarios

> *Note on replacement cost and preference level: Replacement cost belongs at Preference Level 5 (expected/simulated expenditure) in the large majority of ocean accounting applications, because the replacement structure (e.g., a seawall, constructed wetland) is hypothetical: it has not been built and its cost has not been observed. Replacement cost may be classified at Level 4 only in the exceptional case where an equivalent replacement has actually been constructed and the observed construction costs are available from administrative records. See Section 3.10.4 for full guidance on applying these methods.*

¶4 Methods at lower preference levels introduce greater uncertainty and require stronger assumptions. Where feasible, compilers should aim for methods at preference levels 1-3, which rely on observed market data. Because methods at levels 4-5 rest on weaker assumptions, their application should be accompanied by explicit documentation of assumptions and sensitivity analysis.

Decision tree for method selection

¶5 The following decision tree provides a simplified guide to selecting a valuation method based on data availability, following the SEEA EA preference order from most to least preferred. Figure 2.4.2 traces this five-level preference order. Each data-availability gate routes compilers from directly observed prices at Level 1 to modelled expected costs at Level 5.

DRAFT

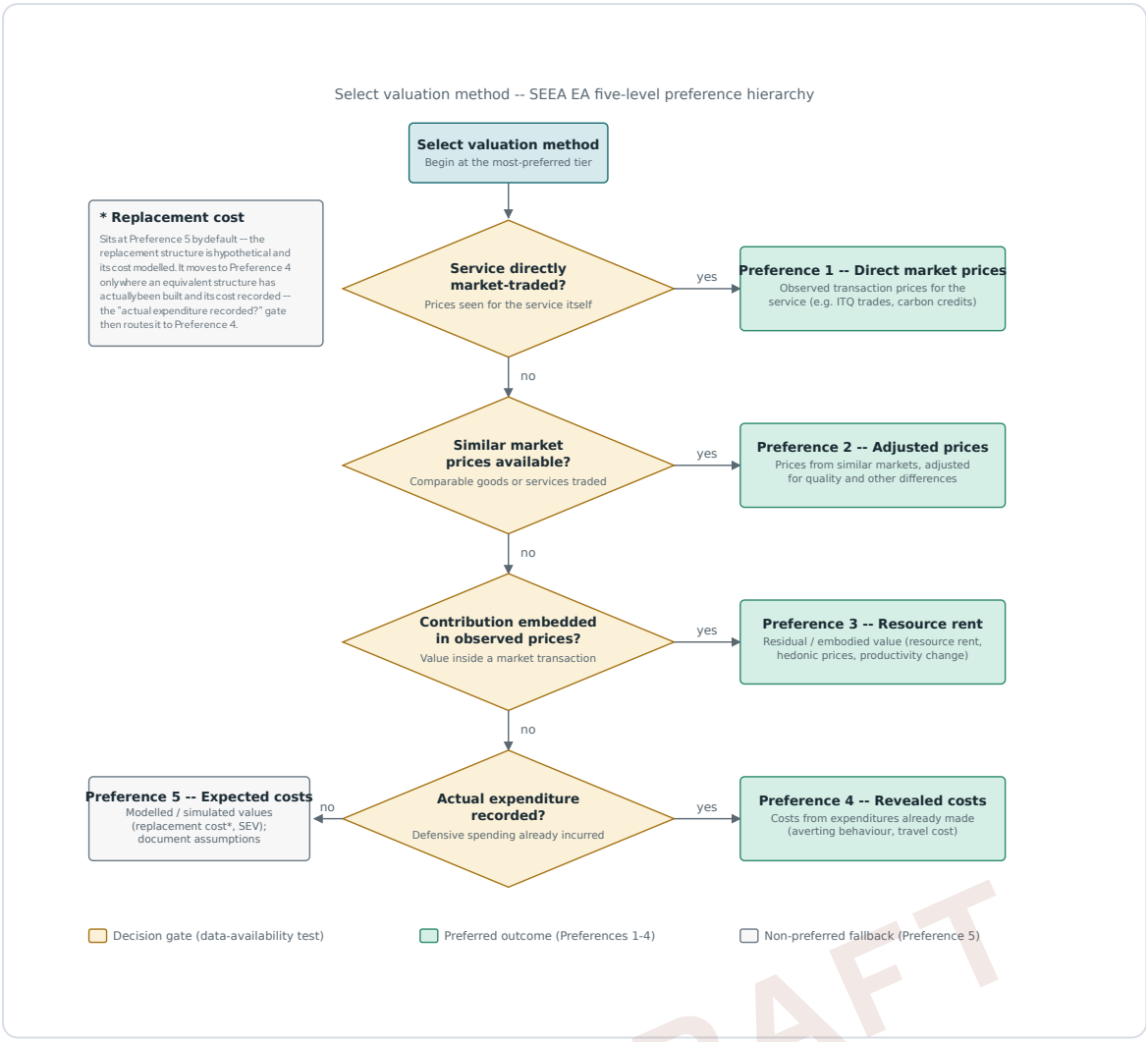


Figure 1.9.1 A five-level SEEA EA preference order routes compilers from direct market prices down to expected costs when higher-tier data are unavailable. [a] Yes at a gate selects that preference. [b] No passes to the next, less-preferred tier. Preference 5 is the non-preferred fallback.

Source: TG-1.9 Valuation Methods, Section 3.4 (five-level preference hierarchy) and Table 1.

Adapted from: SEEA EA 2024, Chapters 8-9 (monetary valuation); preference order per SEEA EA preference hierarchy for valuation methods.

¶6 Sections 3.10.3 and 3.10.4 set out methods for preference levels 1-3 and 4-5 respectively, each with specific ocean accounting examples and worked calculations.

3.10.3 Methods appropriate to accounts (preference levels 1-3)

Directly observable prices (first preference)

¶1 Where prices are directly observable in market transactions, these provide the most reliable basis for valuation. Examples relevant to ocean accounting include:

Ocean Context	Directly Observable Price
Commercial fisheries	Fish quota prices (where ITQ systems exist)
Aquaculture	Site lease/license fees reflecting ecosystem contribution
Coastal forestry	Stumpage values for mangrove timber
Blue carbon	Carbon credit prices from verified offset markets
Water abstraction	Water rights prices (coastal/estuarine contexts)

¶2 These directly observed values reflect the current institutional context and should be applied in accounts even when the resulting values might appear "low" relative to the perceived importance of the ecosystem. As the SEEA EA notes, resource rents for natural resources extracted in open-access contexts will tend toward zero, and this is a well-understood result that reflects institutional arrangements rather than low ecosystem importance.[57]

¶3 Care should be taken to understand the size of markets and their maturity because the use of prices from small or immature markets may not be sufficiently representative for use in ecosystem accounting. To the extent that the recorded values are considered 'low', there may be an interest in estimating complementary values on the basis of alternative institutional contexts and market settings. These hypothetical values should not be recorded in ecosystem accounts but may be presented in complementary accounts.[58]

Prices from similar markets (second preference)

¶4 When market prices for a specific ecosystem service are not observable, prices from markets for similar goods and services may provide an approximation. The SNA states that "if there is no appropriate market in which a particular good or service is currently traded, the valuation of a transaction involving that good or service may be derived from the market prices of similar goods and services by making adjustments for quality and other differences."[59]

¶5 For ocean accounting, this might include:

- ¶6 Using rental prices from comparable coastal land parcels for aquaculture sites
- ¶7 Applying fish prices from similar species/fisheries in other jurisdictions
- ¶8 Using carbon prices from comparable ecosystem types (e.g., terrestrial forest carbon prices for mangrove carbon)
- ¶9 Applying timber prices from comparable terrestrial forests to value mangrove timber provisioning

¶10 **Caution:** Value transfer across different institutional and ecological contexts requires careful adjustment for differences. Institutional mismatch (where source study contexts differ from accounting application contexts) is a risk.[60] The most widespread example of applying this approach in the national accounts is the estimation of the imputed rent for owner-occupied dwellings, where the observed rents paid by tenants are commonly used to apply a 'similar markets' method to estimate rents for owner-occupied dwellings (adjusting for variations in rents associated with the location and characteristics of the dwellings).[61]

Prices embodied in market transactions (third preference)

¶11 These methods estimate ecosystem service values from data on market transactions where the ecosystem contribution is embedded but not directly observable:

¶12 **Residual Value and Resource Rent Methods**

¶13 The resource rent method estimates value by taking gross output value and deducting costs of all other inputs including labour, produced assets, and intermediate inputs.[62] For marine fisheries, this means:

```
Resource rent = Gross output value of catch
              - Intermediate consumption (fuel, ice, repairs)
              - Compensation of employees
              - Taxes on production net of subsidies (including resource access fees,
licence fees, royalties)
              - Consumption of fixed capital (vessel depreciation)
              - Return on produced assets (normal profit on vessel investment)
              - Imputed cost of self-employed labour
```

DRAFT

¶14 The residual represents the contribution of the marine ecosystem to the production value. This method is commonly applied for valuing wild fish provisioning services. This formulation follows the structure set out in SEEA CF Annex A5.1, which defines the resource rent as the residual after deducting all user costs of produced assets and labour from the gross value of output.[62] In the fisheries context, the inclusion of an imputed cost of self-employed labour is essential, as owner-operators are common in many small-scale fisheries, and omitting this cost would inflate the residual. Similarly, the return on produced assets (i.e. normal profit on the capital invested in vessels and gear) must be deducted to isolate the ecosystem contribution from the return to produced capital. Taxes on production net of subsidies, including resource access fees, licence fees, and royalties payable to the resource owner (commonly government), must also be deducted explicitly. In jurisdictions where government retains resource ownership, access fees represent a transfer of the resource rent to the state. Omitting them causes the compiler-calculated residual to overstate the unappropriated rent and risks double-counting government revenue already recorded in national accounts.[63]

¶15 The calculation is subject to variations in prices of outputs and inputs that can be considerable under market conditions, resulting in high annual volatility of estimates. For this reason, statistical offices tend to use 3-5 year moving averages when calculating residual value.[64]

¶16 **Hedonic Pricing**

¶17 Estimates the differential premium on property values derived from proximity to marine and coastal environmental attributes such as beach quality, water clarity, or marine protected areas.[65] This method is particularly relevant for valuing coastal amenity and visual amenity services. Applications of hedonic pricing have grown substantially in recent years, with studies documenting property premiums for nature views, open spaces, beach access, and water quality.[66]

¶18 **Productivity Change Method**

¶19 Estimates value based on the marginal contribution of ecosystem inputs to production functions. For ocean contexts, this includes estimating the productivity contribution of:

- ¶20 Nursery habitat services to fishery production
- ¶21 Water quality services to aquaculture productivity
- ¶22 Coastal vegetation services to agricultural productivity in adjacent lands[67]

¶23 The productivity change method estimates an exchange value that is consistent with the SNA by estimating a production function directly, based on micro-level data on physical inputs and outputs at the site (e.g. farm) level. The econometric estimation of the equation provides a direct estimate of the marginal productivity of the input(s). Multiplying the marginal productivity by the price of the output gives the exchange value of the ecosystem service.[68] Such a method requires the availability of micro data to make the estimation, which can be data intensive.

3.10.4 Methods requiring caution (preference levels 4-5)

Revealed expenditure methods (fourth preference)

¶1 These methods derive prices from actual expenditures on related goods and services that have already been made and are observable in administrative or survey data.

¶2 **Boundary between averting behaviour and replacement cost:** This distinction applies before selecting a Level 4 method. Averting behaviour (defensive expenditure) requires that an actual expenditure has been made and recorded: it is a real cost that appears in national accounts or administrative data. Where the expenditure is hypothetical (the replacement or protective structure has not been built and its cost has not been observed), the correct method is replacement cost at Preference Level 5, not Level 4. Compilers must verify that an actual expenditure record exists before applying a Level 4 cost-based method. The mere plausibility of a future expenditure does not qualify. See Section 3.10.4 for replacement cost guidance.

DRAFT

¶3 **Averting Behaviour (Defensive Expenditure)**

¶4 Based on expenditures to mitigate or eliminate damages from adverse environmental impacts.[69] Ocean examples include:

- ¶5 Expenditure on desalination or treatment when natural water purification services decline
- ¶6 Health expenditure related to poor coastal water quality
- ¶7 Coastal engineering expenditure to protect against degraded natural defences: applicable at Level 4 only where the engineering work has actually been undertaken and costs are on record. Where the works are hypothetical or planned but not yet constructed, the correct method is replacement cost at Level 5

¶8 **Travel Expenditure**

¶9 Uses travel costs as a proxy for recreation service values.[70] The consumer expenditure method, which uses direct out-of-pocket expenditures (transport, fuel, accommodation, fees), provides exchange values appropriate for accounts. This differs from the traditional travel cost method that estimates total willingness to pay including consumer surplus.

¶10 For marine and coastal recreation, consumer expenditure data from tourism statistics can provide a basis for valuation, though care is needed to:

- ¶11 Isolate the marine/coastal component from total trip expenditure
- ¶12 Attribute expenditure to specific ecosystem assets
- ¶13 Avoid double-counting with coastal property amenity values

Expected or simulated expenditure methods (fifth preference)

¶14 Where observed prices and expenditures are not available, methods based on expected or simulated expenditures may be applied:

¶15 **Replacement Cost**

¶16 Estimates the cost of replacing a single ecosystem service using a process that provides equivalent benefits.[71] For ocean accounting, common applications include:

Ecosystem Service	Replacement Cost Basis
Coastal protection (mangroves, reefs)	Engineered sea wall or breakwater
Water purification (wetlands)	Constructed treatment facility
Nursery services (seagrass)	Hatchery and stocking programs
Carbon sequestration	Direct air capture or alternative mitigation

¶17 **Validity conditions:** The replacement must (i) provide exactly the same function, (ii) be the least-cost alternative, and (iii) have evidence of actual demand.[72]

¶18 **Avoided Damage Cost**

¶19 Estimates value based on the costs of damages that would occur due to loss of services.[73] This is particularly relevant for coastal protection services, where avoided damages from storm surge, flooding, and erosion can be estimated using flood risk models. The validity of the avoided damage cost method depends on conditions including that the damages avoided can be related to a specific service, and that people would be willing to pay an amount to actually avoid the damage.[74]

¶20 **Simulated Exchange Value (SEV)**

¶21 Estimates the price and quantity that would prevail if the ecosystem service were traded in a hypothetical market.[75] The SEV method uses demand curves estimated from travel cost or stated preference studies to simulate what price would clear a hypothetical market for the service. Whilst

DRAFT

more complex, this method can provide exchange-value-consistent estimates where other methods are not feasible.

> *Case illustration: UK Marine Natural Capital Accounts (JNCC/Cefas)*
> *The UK Joint Nature Conservation Committee (JNCC) and Centre for Environment, Fisheries and Aquaculture Science (Cefas) compiled an initial set of natural capital accounts for UK marine and coastal ecosystems. At the time of their study, an estimated 36% of UK marine habitats were classified as unmapped or unknown.[76] For those habitats where data were available, the study applied several valuation methods consistent with SEEA principles: replacement cost for waste mediation (phosphorus, nitrogen, BOD) by littoral sediments, coastal saltmarsh, shelf-sea, and deep-sea ecosystems; replacement cost for coastal protection based on the cost of constructing equivalent seawalls; abatement cost for carbon burial in marine sediments; and the resource rent approach for marine fish and shellfish, offshore renewable energy (wind), and abiotic products (marine aggregates). This study illustrates both the feasibility of applying the SEEA EA preference order to marine assets and the practical constraint that incomplete habitat data imposes on full valuation coverage.[77]*

3.10.5 Methods inappropriate for accounts

¶1 Certain valuation methods, whilst useful for other analytical purposes, do not yield exchange values appropriate for direct recording in ecosystem accounts.

Consumer surplus measures

¶2 Methods that estimate total willingness to pay including consumer surplus are not appropriate for direct entry in accounts. Consumer surplus cannot be transferred between transactors and represents value that is not exchanged.[78] However:

- ¶3 Demand curves from such studies can inform SEV calculations
- ¶4 Welfare values remain important for cost-benefit analysis and impact assessment
- ¶5 A "bridge table" between exchange and welfare values can be compiled as a complementary account[79]

Stated preference methods (direct application)

¶6 Contingent valuation and choice experiment results that estimate total willingness to pay should not be directly entered in accounts. Stated preference data that have not been adjusted for exchange value consistency are not appropriate account entries regardless of data availability or the absence of alternative methods.[80]

¶7 **Appropriate use of stated preference data:** If stated preference data are the only available source for a given service, they should be used only as inputs to SEV calculations, adjusting for consumer surplus to derive the simulated exchange value, and clearly flagged as Level 5 estimates requiring sensitivity analysis. They should not be entered as direct account values. Compilers using stated preference data in this way should cross-reference Section 3.10.4 on SEV methodology and document the adjustment procedure explicitly.[80]

¶8 **Other appropriate uses:**

- ¶9 For complementary welfare analysis
- ¶10 In bridge tables linking exchange and welfare values (see Section 3.10.5)

Non-use values

¶11 Non-use values (existence values, bequest values, option values) are not within scope of ecosystem service values in accounts since there are no inherent transactions associated with these

DRAFT

values.[81] This exclusion matters for ocean accounting given the high perceived non-use values associated with:

- ¶12 Iconic marine species (whales, dolphins, sea turtles)
- ¶13 Unique marine ecosystems (coral reefs, kelp forests)
- ¶14 Marine biodiversity in general

¶15 Whilst these values may be relevant for wider policy analysis and public communication, they represent a different measurement concept that should not be mixed with exchange-value-based accounts. Where non-use values are considered important for policy purposes, the SEEA EA framework accommodates their presentation through complementary accounts and thematic analyses. Chapter 12 of the SEEA EA describes how welfare values, including non-use values, can be reported in supplementary tables alongside exchange-value-based accounts, using a bridge-table approach that makes the relationship between the two measurement concepts explicit.[79] This approach allows policymakers to access information on non-use values without compromising the conceptual integrity of the core accounts. For ocean accounting, compilers may wish to consider producing such complementary analyses for ecosystem types or species where non-use values are known to be large relative to exchange values, such as iconic marine habitats and species.

Restoration costs for total asset valuation

¶16 The SEEA EA distinguishes between replacement costs (appropriate for individual services) and restoration costs (the cost of restoring an ecosystem as a whole). Restoration costs should not be used to value ecosystem assets, as this would make it impossible to separately assess the benefits of ecosystem restoration: they would by definition equal the costs.[82] However, restoration costs can provide policy-relevant information in certain contexts and may be presented in complementary accounts.

3.10.6 Worked example: applying the preference order to marine ecosystem services

¶1 The following worked example covers a coastal marine ecosystem and illustrates step-by-step method selection for multiple ecosystem services supplied by a hypothetical coastal accounting area.

DRAFT

Scenario Description

¶2 **Accounting Area:** A coastal region encompasses 500 hectares of mangrove forest, 200 hectares of coral reef, and 5,000 hectares of continental shelf waters. The area supports commercial fisheries (targeting reef and pelagic fish), recreational diving, and provides coastal protection to 10 km of populated coastline. An ITQ system for fishing is not in place; catch is managed through annual total allowable catch (TAC) limits. Carbon markets operate at national level with verified blue carbon offsets for mangrove conservation.

¶3 **Objective:** Compile monetary values for four key ecosystem services (fish provisioning, coastal protection, carbon sequestration, and recreation) using the SEEA EA preference order.

Fish Provisioning Service

¶4 **Step 1: Check for directly observable prices (Preference 1)**

- ¶5 No ITQ market exists → No directly observable quota prices
- ¶6 Fish are sold at observed market prices, but these are product prices not ecosystem service prices

¶7 **Step 2: Check for similar markets (Preference 2)**

- ¶8 A neighboring jurisdiction with comparable species and fishing methods operates an ITQ market where quota prices average USD 800 per tonne
- ¶9 However, institutional differences (this jurisdiction has TAC but no ITQ) mean direct price transfer is not appropriate without adjustment

¶10 **Step 3: Apply prices embodied in transactions (Preference 3)**

- ¶11 **Method selected: Resource rent**
- ¶12 Data available: National fishery statistics provide gross output value, intermediate consumption, employment, and vessel capital stock data

¶13 **Calculation:**

```
Gross output value (landed value):                              USD 5,200,000
Less: Intermediate consumption:                                 USD 1,800,000
Less: Compensation of employees:                                USD 1,200,000
Less: Taxes on production net of subsidies (access fees,
      licence fees, royalties -- nil in this jurisdiction):     USD         0
Less: Consumption of fixed capital:                             USD   400,000
Less: Return on produced assets (5%):                           USD   300,000
Less: Imputed self-employed labour:                             USD   500,000
= Resource rent:                                                USD 1,000,000

Annual catch: 2,000 tonnes
Resource rent per tonne: USD 500
```

> *Note: The taxes/access fees line is shown explicitly as nil here because the illustrative jurisdiction has no royalty or licence fee regime. In jurisdictions where government charges access fees or royalties, this line will carry a positive deduction. Omitting it where fees exist would overstate the resource rent.*

¶14 **Result:** Fish provisioning service valued at USD 500 per tonne using resource rent method (Preference level 3). This represents the ecosystem contribution after deducting all other input costs. See also **TG-1.9** Section 3.2.4: because resource rent is used here, nursery habitat services from the reef should not be separately valued in this account.

DRAFT

Carbon Sequestration Service

¶15 **Step 1: Check for directly observable prices (Preference 1)**

- ¶16 National blue carbon offset market exists for mangrove conservation
- ¶17 Verified carbon credits from mangroves trade at USD 15 per tonne CO2-equivalent
- ¶18 **Method selected: Observed market prices (for credit valuation)**

¶19 **Step 2: Distinguish physical service flow from monetisable verified credits**

¶20 The physical service flow (gross CO2 sequestration) is the quantity recorded in the physical account. The monetary value attaches to the verified offset credits that can be issued against that sequestration. The two quantities differ because verified carbon markets apply permanence buffers and leakage deductions to manage the risk that sequestered carbon is not permanently retained.

¶21 **Calculation:**

```
Physical service flow (gross sequestration):
  Mangrove sequestration rate: 8 tonnes CO2/ha/year
  Mangrove extent: 500 hectares
  Annual gross sequestration: 4,000 tonnes CO2
  → Record 4,000 t CO2/year in the physical supply account

Monetisable verified credits:
  Less: Permanence buffer deduction (15%, illustrative --
        consistent with a moderate-risk Verra VM0033
        buffer contribution for credits specifically):  600 tonnes CO2
  Net credits eligible for market price:              3,400 tonnes CO2

  Note: The 15% buffer is a requirement of the credit instrument,
  not a property of the sequestration service. It applies when
  valuing verified credits; do not apply it when recording the
  physical service flow in the physical account.

Monetary valuation:
  Net credits: 3,400 tonnes CO2
  Market price: USD 15 per tonne CO2
  Annual service value: USD 51,000
```

> *Where no verified credits exist: If the jurisdiction has no operating verified carbon offset market, do not apply prices from other markets directly. Instead, use a Level 5 simulated exchange value method (Section 3.10.4), and document the method and assumptions explicitly.*

¶22 **Result:** Carbon sequestration service valued at USD 51,000 annually using observed carbon credit prices applied to net verified credit units (Preference level 1). The gross physical flow of 4,000 t CO2/year is recorded separately in the physical account.

DRAFT

Coastal Protection Service

¶23 **Step 1: Check for directly observable prices (Preference 1)**

- ¶24 No market for coastal protection services exists
- ¶25 Property owners do not pay for protection services provided by reefs and mangroves

¶26 **Step 2: Check for similar markets (Preference 2)**

- ¶27 No comparable markets for natural coastal protection

¶28 **Step 3: Check for prices embodied in transactions (Preference 3)**

- ¶29 Hedonic pricing study of coastal properties would require extensive data collection
- ¶30 Productivity change method not applicable (no direct production function)

¶31 **Step 4: Assess validity conditions for replacement cost (Preference 5)**

- ¶32 No equivalent seawall has been built in this area; the replacement is hypothetical → **Preference Level 5** applies (not Level 4)
- ¶33 Engineering studies for the region indicate that a seawall providing equivalent protection would cost USD 12,000 per km of coastline

¶34 **Validity conditions test:**

Condition	Evidence	Met?
(i) Equivalent function: the seawall provides the same flood and erosion protection as the reef/mangrove system for the 10 km coastline	Regional coastal engineering survey confirms a 1.2 m freeboard seawall at this location would replicate modelled protection levels under a 1-in-50-year storm event	Yes

Condition	Evidence	Met?
(ii) Least-cost alternative: no cheaper engineered option can provide the same protection	Comparative cost estimates for riprap revetment (USD 18,000/km) and hybrid living shoreline (USD 22,000/km) confirm the seawall at USD 12,000/km is the least-cost engineered substitute	Yes
(iii) Evidence of actual demand: beneficiaries would actually procure the replacement if natural protection were lost	Coastal development master plan for the region includes a contingency seawall provision; two recent development applications cite natural reef as justification for reduced setbacks, confirming revealed demand	Yes

> *If any condition cannot be demonstrated, the method should be applied at Level 5 with correspondingly stronger uncertainty documentation and sensitivity analysis, and the failed condition flagged in the disclosure statement.*

¶35 **Calculation:**

```
Note: Cost figures in this example are purely illustrative and do not represent
actual engineering costs.

Protected coastline: 10 km
Replacement cost: USD 12,000 per km
Annual service value (assuming 50-year asset life and 4% discount):
  = USD 120,000 / 21.48 (annuity factor) = USD 5,586 per year

Alternatively, using direct annual equivalent:
  = (USD 120,000 x 0.04) / (1 - (1.04)^-50) = USD 5,586 per year
```

¶36 **Result:** Coastal protection service valued at USD 5,586 annually using replacement cost method (Preference level 5). Sensitivity analysis should be conducted on asset life (30-70 years) and discount rate (3-5%).

DRAFT

Recreation Service

¶37 **Step 1: Check for directly observable prices (Preference 1)**

- ¶38 Dive operators charge fees, but these are for guide services not for the ecosystem service itself
- ¶39 Marine protected area has no entry fee

¶40 **Step 2: Check for similar markets (Preference 2)**

- ¶41 Nearby marine parks charge entry fees of USD 10 per visitor
- ¶42 However, institutional difference (this site is free-access) means fee cannot be directly applied

¶43 **Step 3: Check for prices embodied in transactions (Preference 3)**

- ¶44 No hedonic property study available for this specific area

¶45 **Step 4: Apply revealed expenditure methods (Preference 4)**

- ¶46 **Method selected: Consumer expenditure**
- ¶47 Tourism statistics record visitor numbers and expenditure on transport, accommodation, and dive operator fees

¶48 **Calculation — raw expenditure:**

```
Annual visitors: 15,000
Average expenditure per visitor on marine recreation: USD 80
  (Transport USD 30, accommodation USD 35, dive fees USD 15)
Total consumer expenditure: USD 1,200,000
```

¶49 **Step 5: Isolate the marine ecosystem component**

¶50 Not all trip expenditure is attributable to the marine ecosystem service. Accommodation costs (USD 35 of USD 80) serve the overnight stay regardless of the marine destination, and they should generally be excluded unless the marine attribute is demonstrably the primary trip driver. One accepted allocation approach uses visitor motivation data:

```
Visitor motivation survey: 65% of visitors cite marine recreation
  as their primary trip motivation (the remainder cite coastal
  amenity, cultural sites, or general relaxation)

Marine-attributable expenditure:
  Transport + dive fees component = USD 45 per visitor
  Marine motivation share applied to accommodation:
    USD 35 x 65% = USD 22.75 per visitor
  Total marine-attributable expenditure per visitor:
    USD 45 + USD 22.75 = USD 67.75

Annual marine-attributable expenditure:
  15,000 visitors x USD 67.75 = USD 1,016,250
```

¶51 Where motivation survey data are not available, a conservative approach is to include only purpose-specific fees (transport and dive fees) and exclude accommodation. Compilers should document the allocation method and reference tourism satellite account methodology for multi-purpose trips.[83]

¶52 **Result:** Recreation service valued at approximately USD 1,016,250 annually using consumer expenditure method with marine motivation allocation (Preference level 4). Care must also be taken to avoid double-counting with coastal property amenity values already captured in any hedonic pricing estimate.

DRAFT

Summary Table

¶53 *Table 3.10.2: Valuation method selection summary*

Ecosystem Service	Method Selected	Preference Level	Annual Value	Rationale
Fish provisioning	Resource rent	3	USD 1,000,000	Observed market data for fish sales; resource rent isolates ecosystem contribution
Carbon sequestration	Market price (net credits)	1	USD 51,000	Blue carbon credit market provides directly observable prices; value applied to net verified credit units after permanence buffer
Coastal protection	Replacement cost	5	USD 5,586	No observed market; replacement hypothetical; validity conditions tested and met
Recreation	Consumer expenditure (marine-allocated)	4	USD 1,016,250	Visitor expenditure data available; marine motivation allocation applied

¶54 **Interpretation:** These four services were selected specifically to be non-overlapping for this illustrative example: they have distinct beneficiary populations (fishing industry, carbon market par-

ticipants, coastal residents, recreational visitors) and draw on distinct ecosystem processes (provisioning, carbon cycling, physical protection, amenity). Because of this non-overlap, the four values can be summed to an indicative total of approximately USD 2,072,836 for this accounting area. In real compilations, compilers must confirm non-overlap before summing service rows (see **TG-1.9** Section 3.2.4 for double-counting cautions, including the specific rule that nursery habitat services must not be separately valued when resource rent is used for fish provisioning). The corrected coastal protection value of USD 5,586 reflects the annuity factor of 21.48 at 4% over 50 years. All values should be presented alongside physical accounts showing mangrove extent, reef condition, fish stock biomass, and visitor numbers.

Ecosystem Asset Valuation — Simplified NPV Illustration

¶55 This section synthesises the four service values from Table 3.10.2 into a simplified ecosystem asset value using the net present value (NPV) approach. This is an introductory illustration only. TG-3.1 provides full guidance on ecosystem asset accounts.

¶56 **Step 1: Annual service flow**

```
Total annual service flow (sum of four services):
  Fish provisioning:      USD 1,000,000
  Carbon sequestration:   USD    51,000
  Coastal protection:     USD     5,586
  Recreation:             USD 1,016,250
  Total:                  USD 2,072,836
```

¶57 **Step 2: Projection assumption**

¶58 For this simplified illustration, assume constant real service flows over the asset life (no growth or decline trend). In practice, compilers should assess whether a trend, positive (e.g., reef restoration) or negative (e.g., climate-related degradation), is observable and use that trend in the projection. TG-3.1 discusses projection methods in detail.

¶59 **Step 3: Discount rate**

¶60 Illustrative rate: **4%** social discount rate (reflecting a mix of collective-benefit services in this portfolio). See **TG-1.9** Section 3.1.2 for guidance on rate selection. Sensitivity analysis is mandatory.

¶61 **Step 4: Time horizon**

¶62 Illustrative horizon: **50 years** (broadly consistent with planning horizons for coastal ecosystems). This is a practical simplification. Ecosystem assets are long-lived, and a perpetuity formula may be more appropriate in some contexts.

¶63 **Step 5: NPV calculation**

```
NPV = Annual flow × Annuity factor (4%, 50 years)
    = USD 2,072,836 × 21.48
    = USD 44,524,517

Annuity factor = [1 - (1 + r)^-n] / r
               = [1 - (1.04)^-50] / 0.04
               = 21.48
```

¶64 *Table 3.10.3: Sensitivity analysis — ecosystem asset NPV*

Discount rate	Time horizon	Annuity factor	NPV
3% (SIDS conservative benchmark)	50 years	25.73	USD 53,334,070
4% (primary illustration)	**50 years**	**21.48**	**USD 44,524,517**
4%	30 years	17.29	USD 35,839,334

DRAFT

Discount rate	Time horizon	Annuity factor	NPV
7%	50 years	13.80	USD 28,605,137
7%	30 years	12.41	USD 25,723,895

¶65 The sensitivity table demonstrates that the asset value is sensitive to both discount rate and time horizon assumptions. The spread between the 3%/50-year and 7%/30-year estimates is nearly twofold. Transparent disclosure of these assumptions is therefore essential. See TG-3.1 for full ecosystem asset account methodology, including how to handle multiple service types with different discount rates, depreciation of ecosystem assets, and time-series consistency.

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

5. References

1. ¶1 SEEA Ecosystem Accounting (2021), para. 6.1, p. 134.
2. ¶2 SEEA Ecosystem Accounting (2021), para. 6.51, Table 6.3, p. 144.
3. ¶3 The Classification of Environmental Protection Activities (CEPA) and Classification of Resource Management Activities (CReMA) are statistical classifications maintained internationally for EGSS compilation. Recent updates — documented in Eurostat (2023) *Environmental Protection Expenditure Accounts — Compilation Guide* and Eurostat's EGSS compilation guide (most recent edition) — have integrated activities previously classified under CReMA 12 (Protection of biodiversity and landscapes) into CEPA 6. See footnote [17] for the consolidated classification note used throughout this Circular.
4. ¶4 SEEA Ecosystem Accounting (2021), Chapter 14, provides guidance on deriving indicators from ecosystem accounts.
5. ¶5 SEEA Ecosystem Accounting (2021), Chapter 14, provides guidance on deriving indicators from ecosystem accounts.
6. ¶6 SEEA Ecosystem Accounting (2021), para. 6.51, pp. 144-145.
7. ¶7 SEEA Ecosystem Accounting (2021), Table 6.3, pp. 144-148. The full reference list includes additional services such as biomass provisioning from wild animals and plants other than fish, genetic material services, and storm mitigation services.
8. ¶8 Adapted from SEEA Ecosystem Accounting (2021), Table 6.3, pp. 144-148.
9. ¶9 SEEA Ecosystem Accounting (2021), paras. 14.20-14.30, describe different types of indicators derivable from accounts.
0. ¶10 SEEA Ecosystem Accounting (2021), para. 6.141, p. 165.
1. ¶11 FAO (2022). *The State of World Fisheries and Aquaculture 2022: Towards Blue Transformation*. Rome: FAO. The biennial SOFIA report provides global and regional fisheries stock-status data (including B/BMSY indicators where available) used as the Tier 1 capacity data source for fish provisioning indicators.
2. ¶12 SEEA Ecosystem Accounting (2021), para. 14.8, p. 310. The distinction between headline and supporting indicators supports both high-level communication and detailed analytical use of ecosystem service accounts.
3. ¶13 SEEA Ecosystem Accounting (2021), para. 7.58, p. 192.
4. ¶14 SEEA Ecosystem Accounting (2021), para. 7.58, p. 192.
5. ¶15 SEEA Central Framework (2012), Chapter 4, Section 4.3.3, describes the Environmental Goods and Services Sector (EGSS) and its relationship to environmental protection expenditure (EPE) and resource management expenditure (RME).
6. ¶16 SEEA Central Framework (2012), paras. 4.92–4.95. The EGSS consists of producers of all environmental goods and services, encompassing environmental protection services (classified by CEPA) and resource management services (classified by CReMA).
7. ¶17 **Consolidated note on the CReMA 12 reclassification.** The Eurostat EGSS compilation guide (most recent edition) and Eurostat (2023) *Environmental Protection Expenditure Accounts — Compilation Guide* reclassify activities previously coded under CReMA 12 ("Protection of biodiversity and landscapes") to CEPA 6. Two distinct activity groups are affected: (a) biodiversity and landscape protection activities (including coastal and marine biodiversity protection and marine protected area management), and (b) fisheries management activities (historically CReMA 12, now also CEPA 6). Compilers using the SEEA CF (2012) classifications, or national adaptations that have not yet adopted the Eurostat reclassification, should check their national adaptation and document the classification convention used. Cross-country comparability is preserved where the reclassification convention is stated in metadata.

DRAFT

8. ¶18 SEEA Central Framework (2012), paras. 4.140–4.152 describe the compilation approach for EGSS accounts using extended supply-use tables.
9. ¶19 SEEA Central Framework (2012), paras. 4.100–4.105; SNA 2025, para. 6.14 (ancillary activities); Eurostat EGSS compilation guide, Section 2.2. Ancillary production — environmental goods or services produced as an input to the producing unit's own principal activity and consumed within the same unit — is embedded in the intermediate consumption of the producing industry and is not separately recorded as EGSS output.
0. ¶20 SEEA Ecosystem Accounting (2021), Table 6.3, p. 145, entry for "Wild fish and other natural aquatic biomass provisioning services."
1. ¶21 SEEA Central Framework (2012), para. 5.399 (definition of gross catch within the aquatic resources extraction section, paras. 5.393–5.430).
2. ¶22 FAO FishStatJ database (https://www.fao.org/fishery/en/statistics/software/fishstatj (https://www.fao.org/fishery/en/statistics/software/fishstatj)) is the FAO's primary annual capture-production data source, used in combination with FAO/RFMO discard estimates and the biennial *State of World Fisheries and Aquaculture* (SOFIA) report for compiling gross catch.
3. ¶23 The consistency between ecosystem service flows and asset account entries provides a fundamental quality check for ocean accounts. See **TG-3.1 Asset Accounts** for detailed guidance.
4. ¶24 SEEA Ecosystem Accounting (2021), paras. 6.98-6.101 discuss the boundary between ecosystem services and abiotic flows for water.
5. ¶25 SEEA Ecosystem Accounting (2021), paras. 6.11–6.17 (definition of and boundary between intermediate and final ecosystem services); para. 7.23 on use-table column structure.
6. ¶26 SEEA Ecosystem Accounting (2021), para. 6.107, p. 157.
7. ¶27 SEEA Ecosystem Accounting (2021), para. 6.110, p. 158.
8. ¶28 SEEA Ecosystem Accounting (2021), para. 6.112, p. 158.
9. ¶29 SEEA Ecosystem Accounting (2021), para. 6.115, p. 159, on user attribution for global climate regulation services.
0. ¶30 SEEA Ecosystem Accounting (2021), Table 6.3, p. 147.
1. ¶31 SEEA Ecosystem Accounting (2021), Table 6.3, p. 147, entry for "Coastal protection services."
2. ¶32 SEEA Ecosystem Accounting (2021), para. 9.72, p. 230.
3. ¶33 Beck, M.W., Losada, I.J., Menendez, P., Reguero, B.G., Diaz-Simal, P., & Fernandez, F. (2018). The global flood protection savings provided by coral reefs. *Nature Communications*, 9: 2186. Documents wave-energy attenuation by coral reefs (typically in the range 70–97%) and provides parameters used in coastal protection effectiveness factors and tiered proxy methods.
4. ¶34 SEEA Ecosystem Accounting (2021), para. 6.15, p. 137.
5. ¶35 SEEA Ecosystem Accounting (2021), Table 6.3, p. 148, entry for "Recreation-related services."
6. ¶36 SEEA Ecosystem Accounting (2021), para. 6.97, p. 156.
7. ¶37 SEEA Ecosystem Accounting (2021), Table 6.3, p. 148, entry for "Visual amenity services."
8. ¶38 SEEA Ecosystem Accounting (2021), Table 6.3, p. 148, entry for "Spiritual, artistic and symbolic services." See also United Nations (2007). *United Nations Declaration on the Rights of Indigenous Peoples*, Article 31 on the right to maintain, control, protect, and develop cultural heritage, traditional knowledge, and traditional cultural expressions.
9. ¶39 SEEA Ecosystem Accounting (2021), para. 1.34, p. 7.
0. ¶40 SEEA Ecosystem Accounting (2021), para. 1.33(c), p. 6, notes that the framework "enables coherent accounting in both physical terms (e.g. hectares or tons) and monetary terms."
1. ¶41 SEEA Ecosystem Accounting (2021), paras. 9.21-9.27 establish the preference order for valuation methods.
2. ¶42 SEEA Ecosystem Accounting (2021), paras. 9.43-9.48, discuss the use of carbon prices for valuation of global climate regulation services. The social cost of carbon is a welfare-based concept that does not align directly with the exchange value framework of the SNA and SEEA.
3. ¶43 Based on SEEA Ecosystem Accounting (2021), Chapter 14 guidance on presentation and communication of indicators.
4. ¶44 Bradley, C., Clement, S., Vardon, M., Milligan, B., & Kagohashi, K. (2026). Operationalising the concept of critical natural capital to understand and manage nature dependency risk. *Ecosystem Services*, *77*, 101799, §§6–7, Table 1, pp. 6–8. https://doi.org/10.1016/j.ecoser.2025.101799 (https://doi.org/10.1016/j.ecoser.2025.101799). An importance hierarchy (basic needs; good health and safety; essential and non-essential wellbeing) for deciding which ecosystem services matter most, for whom and for what purpose, applied to the SEEA ecosystem service classes, with the split between levels 3 and 4 left for countries to set.
5. ¶45 **Note on linear vs areal intensity metrics for coastal protection.** Coastal protection intensity can be expressed as either (a) an *areal* metric — ecosystem area per unit of beneficiary shoreline protected (km²/km), useful where the protective function is distributed across the ecosystem's full area such as in mangrove belts that absorb storm surge volumetrically, or (b) a *linear* metric — length of beneficiary shoreline per kilometre of ecosystem frontage, useful where the protective function is determined by the linear interface with the coast such as in coral reefs and dune systems. The choice should follow the dominant physical mechanism for the ecosystem in question and must be disclosed in metadata. Reporting an areal denominator for ecosystems whose protective function is essentially linear (or vice versa) will produce misleading intensity figures.
6. ¶46 SNA 2025, para. 4.131 (formerly SNA 2008, para. 3.118). Exchange values are defined as values at which goods, services, labour, or assets are exchanged or could be exchanged for cash.

DRAFT

7. ¶47 SNA 2025, para. 4.132 (formerly SNA 2008, para. 3.119). Market prices are amounts willing buyers pay to acquire something from willing sellers.
8. ¶48 SEEA EA 2021, para. 8.9. Exchange values differ from welfare values commonly used in environmental cost-benefit analysis, which include consumer surplus.
9. ¶49 NCAVES/MAIA 2022, Section 2.3.2. Consumer surplus is the difference between total willingness to pay and what is actually paid; accounts record the latter.
0. ¶50 SNA 2025, para. 4.130. The integrated framework measures current exchange value rather than attempting to determine utility of flows and stocks.
1. ¶51 NCAVES/MAIA 2022, Section 2.2. Ecosystem services are excluded from SNA production boundary; SEEA EA extends this boundary.
2. ¶52 NCAVES/MAIA 2022, Figure 1. Provisioning services contribute to SNA benefits; regulating and cultural services may contribute to SNA or non-SNA benefits.
3. ¶53 SEEA EA 2021, paras 5.25-5.28. Classification of ecosystem service beneficiaries by whether their benefits are within or outside the SNA production boundary.
4. ¶54 UNSC Decision 52/101, March 2021. Specifies different status for physical accounts (standard) versus valuation chapters (recognized recommendations).
5. ¶55 SNA 2025 was adopted by UNSC at its fifty-fifth session (2024), replacing SNA 2008. The SEEA EA 2021 is not amended by SNA 2025; its valuation recommendations remain operative pending future revision of SEEA EA.
6. ¶56 SEEA EA 2021, para. 9.27. Valuation methods should be applied in order of preference based on proximity to observed market prices.
7. ¶57 SEEA EA 2021, para. 9.29. Low values may reflect existing institutional arrangements; this is well understood in economics literature (open-access resources tend toward zero rent).
8. ¶58 SEEA EA 2021, para. 9.30. Care should be taken to understand market size and maturity; hypothetical values under alternative institutional contexts may be presented in complementary accounts.
9. ¶59 SNA 2025, para. 4.137 (formerly SNA 2008, para. 3.123). Similar markets approach adjusts for quality and other differences.
0. ¶60 NCAVES/MAIA 2022, Section 6.1. Value transfer requires consideration of institutional and ecological context differences between source and application sites.
1. ¶61 NCAVES/MAIA 2022, para. 3.3.2. The most widespread example of applying the similar markets approach in national accounts is the estimation of imputed rent for owner-occupied dwellings.
2. ¶62 SEEA CF 2012, Annex 5.1. Resource rent calculation deducts all factor payments from output value.
3. ¶63 SEEA CF 2012, Annex 5.1; SEEA EA 2021, para. 9.31. In jurisdictions where government retains resource ownership, access fees represent a transfer of the resource rent to the state and must be deducted to prevent double-counting government revenue already recorded in national accounts.
4. ¶64 NCAVES/MAIA 2022, Section 3.2.2.1. The calculation is subject to variations in prices of outputs and inputs that can be considerable under market conditions, resulting in high annual volatility of estimates. For this reason, statistical offices tend to use 3-5 year moving averages.
5. ¶65 NCAVES/MAIA 2022, Section 3.2.3.3. Hedonic pricing estimates differential premium on property value from environmental attributes.
6. ¶66 NCAVES/MAIA 2022, para. 3.2.3.3. Applications of hedonic pricing have grown substantially in recent years with studies documenting property premiums for nature views, open spaces, beach access, and water quality.
7. ¶67 SEEA EA 2021, para. 9.38-9.39. Productivity change method estimates marginal productivity of ecosystem inputs to production.
8. ¶68 NCAVES/MAIA 2022, Section 3.2.3.2. The productivity change method estimates an exchange value that is consistent with the SNA by estimating a production function directly based on micro-level data. The econometric estimation provides a direct estimate of the marginal productivity of the input(s).
9. ¶69 SEEA EA 2021, para. 9.45-9.46. Averting behaviour method based on expenditures to mitigate adverse environmental impacts.
0. ¶70 NCAVES/MAIA 2022, Section 3.2.4.2. Consumer expenditure method uses travel expenditures directly as exchange values.
1. ¶71 SEEA EA 2021, para. 9.50. Replacement cost estimates cost of replacing service using process providing same benefits.
2. ¶72 NCAVES/MAIA 2022, para. 3.2.5.1. The validity of the replacement cost method depends on three conditions: the substitute can provide exactly the same function; the substitute is the least-cost alternative; and evidence indicates an actual demand for the substitute.
3. ¶73 SEEA EA 2021, para. 9.52-9.53. Avoided damage cost based on damages that would occur from service loss.
4. ¶74 NCAVES/MAIA 2022, para. 3.2.5.2. The validity of the avoided damage cost method depends on conditions including that the damages avoided can be related to a specific service, and that people would be willing to pay an amount to actually avoid the damage.
5. ¶75 SEEA EA 2021, para. 9.55. Simulated exchange value estimates price and quantity from hypothetical market.
6. ¶76 JNCC and Cefas. Initial marine natural capital account for the UK. At the time of the study, approximately 36% of UK marine habitats were classified as unmapped or unknown.
7. ¶77 JNCC and Cefas. The study applied replacement cost methods (waste mediation, coastal protection), abatement cost (carbon burial), and resource rent (fish and shellfish, offshore wind, marine aggregates) consistent with

DRAFT

SEEA principles.

8. ¶78 NCAVES/MAIA 2022, Section 2.3.2. Consumer surplus cannot be transferred between transactors; accounts do not include it.
9. ¶79 SEEA EA 2021, Chapter 12 describes complementary accounts including bridge tables between exchange and welfare values.
0. ¶80 NCAVES/MAIA 2022, Section 3.2.5.4; SEEA EA 2021, para. 9.55. Stated preference data must be adjusted to derive a simulated exchange value before any use in accounts; they may not be entered as direct account values.
1. ¶81 SEEA EA 2021, Section 6.3.4. Non-use values are not within scope of ecosystem service values.
2. ¶82 SEEA EA 2021, Section 9.3.7 (para. 9.58) and Chapter 12 (Section 12.3.2). The restoration cost method is positioned for measuring ecosystem degradation rather than for total asset valuation.
3. ¶83 NCAVES/MAIA 2022, Section 3.2.4.2; tourism satellite account methodology for multi-purpose trips. Where visitor motivation data are unavailable, purpose-specific fees (transport, activity fees) provide a conservative lower-bound estimate that excludes accommodation costs.

DRAFT

Structure and Function of the Ocean Economy

Compiles indicators characterising the structure and function of the ocean economy: sector composition by industry classification.

Version 0.9.1 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

OUTCOME

After working through this Circular, readers will be able to compile indicators characterising the structure and function of the ocean economy: sector composition by industry classification, sectoral shares of gross value added (GVA) and employment, growth and productivity indicators, net ocean GVA adjusted for resource depletion, and trade and investment patterns. The guidance also provides a step-by-step compilation procedure for extracting ocean economy sub-matrices from national supply and use tables and deriving structural indicators from them.

The guidance responds to high demand from governments seeking to characterise their ocean economies for national budget processes, economic planning, and international reporting—including reporting against Sustainable Development Goal 14 (Life Below Water), particularly target 14.7 on economic benefits from sustainable use of marine resources. These indicators build directly on the ocean economy thematic and extended accounts described in TG-3.3 Economic Activity Relevant to the Ocean and support applications in national budget processes addressed in TG-1.1 OA and National Budget Processes. The relationship between ocean economy structure and multilateral environmental agreement indicators, including SDG 14, is addressed further in TG-2.10 MEA Indicators.

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 3
3.1 Ocean Economy Structure Framework 4
3.2 Sector Composition Indicators 7
3.3 Growth and Productivity Indicators 11
3.4 Net Ocean GVA 12
3.5 Employment Structure 13
3.6 Trade and Investment Indicators 15
3.7 Compilation Procedure 17
3.8 Compilation Considerations 18
4. Acknowledgements 19
5. References 19

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Structure and Function of the Ocean Economy (2026) (GOAP Technical Guidance on Ocean Accounting, TG-2.5, v0.9.1). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-2/2-5-ocean-economy-structure/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

1. Outcome

¶1 After working through this Circular, readers will be able to compile indicators characterising the structure and function of the ocean economy: sector composition by industry classification, sectoral shares of gross value added (GVA) and employment, growth and productivity indicators, net ocean GVA adjusted for resource depletion, and trade and investment patterns. The guidance also provides a step-by-step compilation procedure for extracting ocean economy sub-matrices from national supply and use tables and deriving structural indicators from them.

¶2 The guidance responds to high demand from governments seeking to characterise their ocean economies for national budget processes, economic planning, and international reporting—including reporting against Sustainable Development Goal 14 (Life Below Water), particularly target 14.7 on economic benefits from sustainable use of marine resources. These indicators build directly on the ocean economy thematic and extended accounts described in **TG-3.3 Economic Activity Relevant to the Ocean** and support applications in national budget processes addressed in **TG-1.1 OA and National Budget Processes**. The relationship between ocean economy structure and multilateral environmental agreement indicators, including SDG 14, is addressed further in **TG-2.10 MEA Indicators**.

2. Requirements

¶1 **Essential prerequisites:**

- ¶2 **TG-0.1 General Introduction to Ocean Accounts** – for the conceptual framework and key components of Ocean Accounts
- ¶3 **TG-3.3 Economic Activity Relevant to the Ocean** – for the methodological framework for compiling ocean economy thematic and extended accounts, including industry classifications and supply and use tables

¶4 **Helpful background:**

- ¶5 **TG-0.2 Overview of Relevant Statistical Standards** – for the international statistical standards underpinning ocean accounting, including the SNA 2025, SEEA, ISIC classification, and the methodological principles that govern thematic and extended accounts

¶6 **Framework Position**

¶7 This Circular addresses how ocean accounts characterise the structure of the ocean economy through monetary flows between economic sectors and ocean-related assets. In the Ocean Accounts Framework (TG-0.1 Figure 0.1.2):

Edge	Direction	Description
E3	FG1 ↔ SG1	Monetary flows between assets and economic sectors

3. Guidance Material

¶1 Governments preparing national budgets need to demonstrate the ocean economy's contribution to GDP, employment, and exports (**TG-1.1 OA and National Budget Processes**). Budget officials require quantified evidence of a sector's contribution to national income and employment to assess the rationale for public expenditure on ocean management, fisheries governance, port infrastructure, and marine environmental protection. The indicators in this Circular provide the analytical tools for these assessments, translating the detailed accounting data compiled under **TG-3.3** into policy-ready metrics that can populate the budget presentation structures described in TG-1.1

DRAFT

Section 3.3. Specifically, TG-1.1 identifies a four-row indicator structure—GDP contribution, employment, exports, and fish protein supply—that budget submissions should address; the indicator derivation methods in this Circular set out how compilers produce each of these figures from ocean economy accounts.

¶2 This Circular presents a framework for deriving structural and functional indicators from ocean economy accounts. The approach follows established practices from the System of National Accounts (SNA 2025)[1], draws on analogous approaches developed for tourism in the Statistical Framework for Measuring the Sustainability of Tourism (SF-MST)[2], and builds on the ocean economy thematic and extended accounting methodology described in the SEEA Ecosystem Accounting[3]. The SF-MST is a useful analogue because, like ocean economy measurement, tourism measurement involves delineating a functional segment of the economy that cuts across multiple ISIC industries rather than corresponding neatly to a single industrial classification, and the indicator derivation approaches developed for tourism can be adapted effectively for ocean economy structural analysis.

3.1 Ocean Economy Structure Framework

¶1 The structure of the ocean economy describes how economic activity is distributed across different industries, products, and institutional sectors. A full structural analysis enables comparison of the ocean economy to the broader national economy, identification of dominant and emerging sectors, and assessment of concentration and diversification. Figure 2.5.1 illustrates the end-to-end data pipeline that produces these structural indicators, from raw statistical inputs through harmonisation and the supply-use table to the indicators reported in budget and MEA applications.

DRAFT

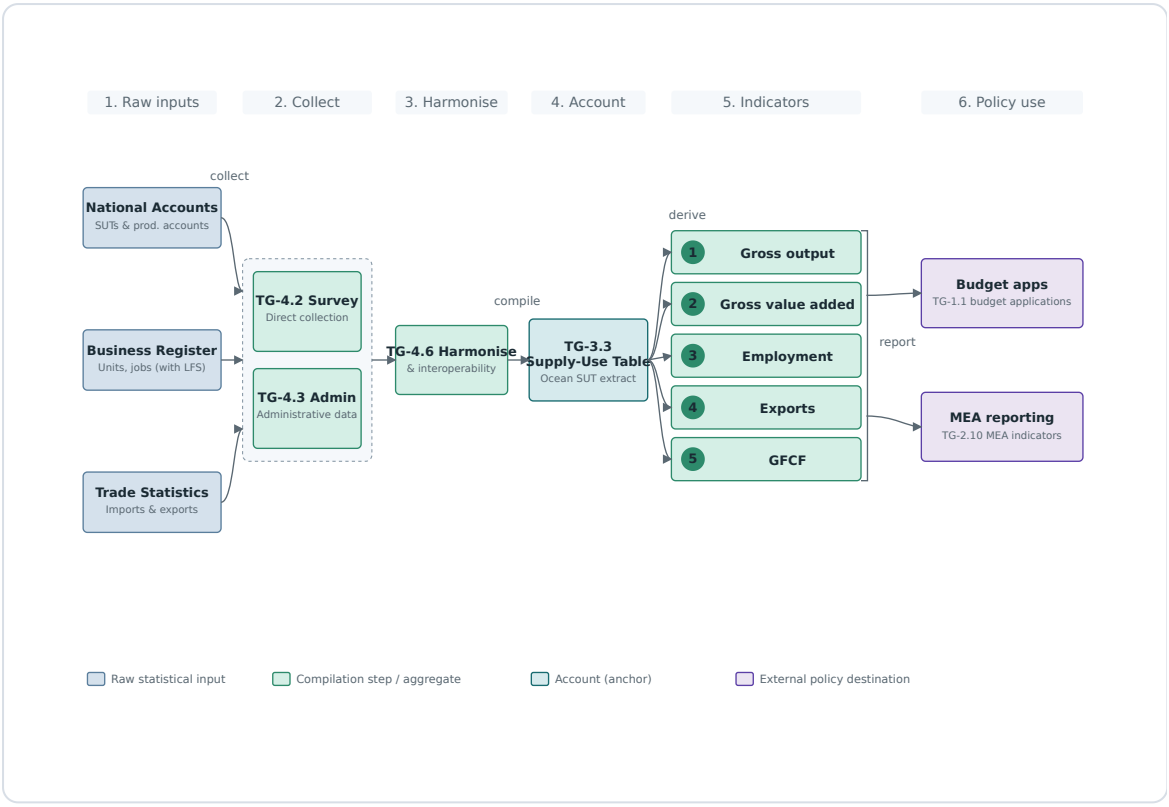


Figure 2.5.1 National statistical inputs flow through collection and harmonisation into a supply-use table that yields ocean economy indicators. Five first-order aggregates (output, GVA, employment, exports, GFCF) feed budget and MEA uses; second-order indicators sit downstream.

Source: TG-2.5 draft §3.1 (Supply-Use Table to indicator derivation trace) and §3.7 (compilation procedure / data pipeline); SNA 2025 Ch.15 (supply and use tables) and Ch.7 (production account); ISIC Rev.4 (UN 2008) for ocean industry classification.

Adapted from: SF-MST (UNWTO 2024) tourism measurement framework -- the draft's primary methodological analogue; OECD *The Ocean Economy in 2030* (2016).

DRAFT

Related terminology

¶1 *Ocean economy*, *marine economy*, *blue economy* and *sustainable ocean economy* are not interchangeable, and the distinctions between them are set out in **TG-1.0 Ocean Accounting and the Blue/Ocean Economy** Section 3.2, together with the rule that a published account must disclose which term it uses. The indicators in this Circular measure the **ocean economy** as scoped in **TG-3.3**. They support blue economy reporting but do not by themselves constitute a blue economy account – see TG-1.0 Section 3.3 for what an account can and cannot certify.

Analytical dimensions

¶1 Structural analysis of the ocean economy operates across four key dimensions [4]:

1. ¶2
   Industry composition – the distribution of ocean economic activity across industries classified according to ISIC, revealing which types of production dominate the ocean economy (e.g., fishing, shipping, offshore energy)
2. ¶3
   Product composition – the distribution of ocean-characteristic products according to CPC, revealing what goods and services the ocean economy produces
3. ¶4
   Institutional sector composition – the distribution of ocean economic activity by institutional sector (corporations, government, households, non-profit institutions), revealing ownership and control patterns

4. ¶5
   Spatial composition — the distribution of ocean economic activity across regions or coastal zones, revealing geographic concentration and regional dependencies. Spatial analysis connects to the treatment of coastal tourism in **TG-3.3** Section 3.4 and may inform future guidance on regional ocean accounts compilation[5].

Geographic boundaries

> ¶1 ⓘ **Geographic Boundary Decisions**
> ¶2 The geographic definition of the ocean economy requires both a seaward boundary and an inland boundary, and both are settled in the account rather than in the indicators derived from it. The seaward boundary is normally the 200-nautical-mile Exclusive Economic Zone established under the United Nations Convention on the Law of the Sea (UNCLOS 1982). The inland boundary is a country-specific decision, set out with its documentation and disclosure requirements in **TG-3.3** Section 3.2.
> ¶3 For the indicators below, two consequences follow. A share computed on one country's boundary is not comparable with the same share computed on another's unless both disclose the boundary they applied. A boundary that moves between reference periods makes the trend in an indicator uninterpretable, whether or not the level is correct in each period[6].

Relationship to thematic and extended accounts

¶1 Structural indicators are derived from the ocean economy thematic and extended accounts described in **TG-3.3 Economic Activity Relevant to the Ocean**. For the thematic and extended accounts framework (SNA 2025 Chapter 38), see **TG-0.2 Standards and Frameworks**. The ocean economy accounts described in this Circular are thematic accounts in the SNA 2025 sense: they disaggregate and rearrange items within the integrated framework of national accounts. The supply and use tables (SUTs) compiled for the ocean economy provide the 'data foundation' for structural analysis[7]. From balanced SUTs, the following can be derived:

- ¶2 Output by industry and product
- ¶3 Gross value added by industry
- ¶4 Employment by industry
- ¶5 Imports and exports of ocean-characteristic products
- ¶6 Gross fixed capital formation by industry

¶7 These aggregates form the basis for the indicators presented in subsequent sections.

Construction methods

¶1 Ocean economy accounts can be constructed using two approaches, which differ in data requirements and analytical scope[6]:

¶2 **Type 1 (thematic approach)** selects value-added data for designated ocean industries directly from existing national accounts production data. Each ocean industry's GVA is identified from the national production account and reported separately. This approach is lighter-weight, appropriate where fully balanced supply and use tables are not available, and lends itself to regional disaggregation more readily than the supply-use approach. Price adjustment uses a broad producer price index at the industry level. The core four indicators — gross output, GVA, employment, and GFCF — can be compiled from this approach.

¶3 **Type 2 (supply-use framework)** fully integrates ocean accounts within national input-output tables, measuring all inter-industry relationships at both product and industry level. This enables estimation of indirect and induced economic effects, reveals linkages between ocean industries and the rest of the economy, and requires product-level price deflators for volume measurement. This is the approach elaborated in §3.7 of this Circular[8].

¶4 Compilers should select the approach matched to their data infrastructure. Type 1 is a valid and publishable starting point; migration to Type 2 is recommended as the end-state when fully bal-

DRAFT

anced SUTs are available.

¶5 **Note on production versus expenditure approaches:** Ocean accounts are built on the **production (value-added) approach** to GDP measurement. Whilst many countries publish their headline GDP figure using the expenditure approach (consumption + investment + government expenditure + net exports), the expenditure approach yields aggregate final demand totals and does not identify industry-level contributions. Both approaches yield the same GDP total under SNA 2025, but only the production approach enables identification of ocean economy industry composition. Compilers working within statistical systems that foreground expenditure-side figures should ensure that production-account data are accessed for ocean industry disaggregation.

SUT-to-indicator derivation trace

¶1 The derivation of structural indicators follows a specific path from the cells of the ocean economy SUTs compiled under **TG-3.3** Section 3.4 (Table 1) to the indicators presented in this Circular. Compilers should trace each indicator to its source aggregate to ensure consistency between accounts and indicators:

- ¶2 **GVA share by industry** – the GVA row in the Use Table provides gross value added for each ocean industry column (e.g., Marine Fishing, Aquaculture, Shipping, Ports, Tourism). Each cell is the numerator for the sector GVA share indicator in Section 3.2.
- ¶3 **Employment share by industry** – the labour inputs row (hours worked or persons employed) at the bottom of the Use Table provides the numerator for the employment share indicator.
- ¶4 **Export share** – the Exports column in the Use Table, summed across ocean-characteristic product rows (fish products, transport services, tourism services), provides the ocean economy exports aggregate used in Section 3.5.
- ¶5 **Investment indicators** – the GFCF column in the Use Table records capital formation by product type; the GFCF row by industry provides the industry-level investment data for investment rate calculations.
- ¶6 **Productivity** – labour productivity for each ocean industry is computed by dividing the GVA cell for that industry by the corresponding labour inputs cell.

¶7 This explicit mapping ensures that every indicator in this Circular can be traced back to a specific cell or aggregate in the ocean economy SUTs, providing a clear audit trail from accounts to indicators to policy applications.

DRAFT

3.2 Sector Composition Indicators

¶1 Sector composition indicators describe the relative importance of different industries within the ocean economy, enabling identification of dominant sectors, comparison with national industry structure, and tracking of structural change over time.

Classification framework

¶1 Ocean economy industries are classified using the International Standard Industrial Classification (ISIC)[9]. Following the categorisation in **TG-3.3** Section 3.3, ocean industries are grouped as:

¶2 **Core ocean-dependent industries** (wholly ocean-related). Core ocean-dependent industries are identified at the division or class level depending on whether the entire division is ocean-related or only specific classes within a broader division:

- ¶3 ISIC Division 03: Fishing and aquaculture
  - ¶4 Class 0311: Marine fishing
  - ¶5 Class 0321: Marine aquaculture
- ¶6 ISIC Division 50: Water transport
  - ¶7 Class 5011: Sea and coastal passenger water transport

  - ¶8 Class 5012: Sea and coastal freight water transport
- ¶9 ISIC Division 06: Extraction of crude petroleum and natural gas (offshore portion)
- ¶10 ISIC Class 3510: Electric power generation, transmission and distribution (offshore wind, tidal, wave portion)

¶11 **Ocean-related industries** (partially ocean-related, requiring estimation of ocean share):

- ¶12 ISIC Class 1020: Processing and preserving of fish, crustaceans and molluscs
- ¶13 ISIC Class 3011: Building of ships and floating structures
- ¶14 ISIC Class 3012: Building of pleasure and sporting boats
- ¶15 ISIC Class 5222: Service activities incidental to water transportation
- ¶16 ISIC Class 5224: Cargo handling (port cargo handling share)
- ¶17 ISIC Class 5510: Short-term accommodation activities (coastal tourism share)
- ¶18 ISIC Class 7210: Research and experimental development (marine research share)
- ¶19 ISIC Class 8423: Public order and safety activities (coast guard, maritime enforcement share)
- ¶20 ISIC Class 9319: Other sports activities (marine sports and recreation share)

¶21 This listing is illustrative and should be verified against the fuller classification in **TG-3.3** Section 3.3, which provides the authoritative industry concordance for ocean economy accounts. Compilers should adapt the industry scope to their national circumstances and document the specific ISIC classes included. For offshore oil and gas extraction and offshore renewable energy, additional classification detail is provided in **TG-3.10 Offshore Energy**.

Scope decisions and international practice

¶1 There is no single agreed scope for the ocean economy, and national programmes legitimately differ. The 35-country review of ocean account definitions, the Portugal / United States / Norway comparison and the EU and OECD measurement programmes are in **TG-1.0 Ocean Accounting and the Blue/Ocean Economy** Sections 3.1 and 3.6; the industry scope a compiler actually applies is **TG-3.3** Section 3.4. The consequence for the indicators below is that a share computed on one country's scope is not comparable with the same share computed on another's unless both disclose the scope, the tier and the ocean-ratio estimation level.

DRAFT

Key composition indicators

¶1 The following indicators characterise sector composition[10]:

¶2 **Output share by industry**

$$\text{Output share}_i = \frac{\text{Output}_i}{\sum_j \text{Output}_j} \times 100$$

¶3 where i denotes an individual ocean industry and j indexes all ocean industries.

¶4 **GVA share by industry**

$$\text{GVA share}_i = \frac{\text{GVA}_i}{\sum_j \text{GVA}_j} \times 100$$

¶5 This indicator reveals the relative contribution of each industry to total ocean economy value added. In the Ocean Accounts Framework (TG-0.1), the GDP contribution, industry output, and supply-use relationships measured through these structural indicators correspond to Edge E3 (mone-

tary flows between assets and economic sectors), capturing the bidirectional monetary flows that characterise the ocean economy's productive structure.

¶6 **Employment share by industry**

$$\text{Employment share}_i = \frac{\text{Employment}_i}{\sum_j \text{Employment}_j} \times 100$$

¶7 Employment may be measured as number of persons employed, number of jobs, hours worked, or full-time equivalent (FTE) positions[11]. For headline reporting, persons employed is recommended as the default measure, with FTE reported as a supplementary indicator where seasonal or part-time employment is significant.

¶8 **Herfindahl-Hirschman Index (HHI) for concentration**

$$\text{HHI} = \sum_i \left(\frac{\text{GVA}_i}{\sum_j \text{GVA}_j} \times 100 \right)^2$$

¶9 The HHI ranges from near zero (highly diversified) to 10,000 (single industry). In antitrust analysis, an HHI above 2,500 is conventionally treated as indicating high concentration. For ocean economy sectoral analysis, however, compilers should interpret HHI values with caution. Small island developing States (SIDS) and countries with narrow resource endowments may exhibit structurally higher concentration in their ocean economies—dominated, for example, by fisheries and tourism—without this necessarily indicating a policy concern in the same way that high market concentration does. Compilers should present the HHI alongside the detailed composition data in Table 3.1 so that users can assess whether concentration reflects structural characteristics of the economy or an imbalance that warrants policy attention.

DRAFT

Comparative analysis

¶1 Recommended comparisons include:

1. ¶2
   Comparison to national economy — comparing ocean industry shares to their shares in the national economy reveals specialisation patterns
2. ¶3
   Comparison over time — tracking composition changes reveals structural transformation (e.g., growth of offshore energy relative to traditional fishing)
3. ¶4
   International comparison — comparing ocean economy structure across countries reveals different endowments and development patterns

¶5 Table 3.1 presents sector composition indicators for a hypothetical medium-income coastal state ("Country A") with a total GDP of approximately USD 50 billion, total employment of 10 million persons, and an ocean economy representing 3.5 per cent of national GVA. All monetary values are expressed in millions of USD.

¶6 **Table 3.1: Ocean economy sector composition (Country A, illustrative)**

Industry (ISIC)	Output (million USD)	GVA (million USD)	Employment (persons)	Output share (%)	GVA share (%)	Employment share (%)
Coastal and marine tourism (partial 5510, 5610, 9319)	933	560	153,000	27.2	32.0	51.0
Offshore oil and gas (06)	933	420	24,000	27.1	24.0	8.0
Maritime transport and ports (501, 5222, 5224)	630	315	36,000	18.3	18.0	12.0
Marine living resources (0311, 0321, 1020)	318	175	54,000	9.3	10.0	18.0
Shipbuilding and repair (3011, 3012)	308	123	18,000	9.0	7.0	6.0
Marine renewable energy (3510 partial)	140	70	6,000	4.1	4.0	2.0
Other ocean industries (7210, 8423, etc.)	174	87	9,000	5.0	5.0	3.0
Total ocean economy	**3,436**	**1,750**	**300,000**	**100.0**	**100.0**	**100.0**

¶7 The HHI computed from the GVA shares in Table 3.1 is approximately 2,114 (= 32.0^2 + 24.0^2 + 18.0^2 + 10.0^2 + 7.0^2 + 4.0^2 + 5.0^2), indicating moderate concentration. Two sectors—coastal and marine tourism and offshore energy—together account for 56 per cent of ocean GVA, a pattern common in medium-income coastal states with established hydrocarbon production.

¶8 To make comparative analysis concrete, Table 3.1a presents a recommended format for comparing ocean economy structure against the national economy. This comparative presentation, adapted from the SF-MST approach to characterising tourism industries (SF-MST Table 3.3), enables identification of sectors in which the ocean economy is relatively more or less intensive than the national economy as a whole.

¶9 **Table 3.1a: Ocean economy versus national economy structure (Country A, illustrative)**

Indicator	Ocean economy	National economy	Ocean share of national (%)
Total output (million USD)	3,436	100,000	3.4
GVA (million USD)	1,750	50,000	3.5
Employment (persons)	300,000	10,000,000	3.0
GVA per person employed (USD)	5,833	5,000	116.7
Average compensation per employee (USD)	3,208	3,000	106.9
GFCF (million USD)	380	11,000	3.5
Exports (million USD)	620	12,000	5.2

¶10 The data in Table 3.1a reveal that whilst the ocean economy accounts for 3.5 per cent of national GVA, it accounts for only 3.0 per cent of employment, implying slightly above-average labour productivity. The ocean economy's share of exports (5.2 per cent) exceeds its share of national GVA, indicating an outward orientation driven by fish product exports and maritime transport services.

Budget-ready summary

¶1 Table 3.1b maps the indicators derived from Tables 3.1 and 3.1a directly to the four-row budget presentation structure specified in **TG-1.1** Section 3.3 (Table 1). This table provides the format in

which ocean economy indicators should be presented in national budget submissions to demonstrate the sector's contribution to the national economy.

¶2 **Table 3.1b: Ocean economy contribution — budget presentation format (Country A, illustrative)**

Indicator	Ocean economy	National total	Ocean share (%)
GDP contribution, measured as GVA at basic prices (million USD)	1,750	50,000	3.5
Employment (thousand persons)	300	10,000	3.0
Exports (million USD)	620	12,000	5.2
Fish protein supply (thousand tonnes)	285	340	83.8

3.3 Growth and Productivity Indicators

¶1 Growth and productivity indicators measure the dynamic performance of the ocean economy, revealing whether it is expanding or contracting, whether growth is generating productivity improvements, and how ocean economy performance compares to the broader economy.

Growth indicators

¶1 **Nominal growth rate**

$$\text{Growth rate}_t = \frac{X_t - X_{t-1}}{X_{t-1}} \times 100$$

¶2 where X is the variable of interest (output, GVA, employment) and t is the reference period.

¶3 **Real growth rate** — adjusts for price changes using appropriate deflators[12]:

$$\text{Real growth rate}_t = \frac{X_t/P_t - X_{t-1}/P_{t-1}}{X_{t-1}/P_{t-1}} \times 100$$

¶4 where P is the relevant price index. The choice of deflator is important for ocean economy aggregates because price movements in ocean industries can diverge substantially from economy-wide trends. Offshore energy output, for example, is strongly influenced by international oil and gas price indices, whilst maritime transport output responds to freight rate indices such as the Baltic Exchange indices. Compilers should use industry-specific deflators where available rather than applying the aggregate GDP deflator to all ocean industries. Where sector-specific deflators are unavailable, compilers should document the deflator used and assess the potential bias introduced. Methodological guidance on deflation and volume measurement is provided in SNA 2025 Chapter 18, and further context on the statistical standards governing price and volume measures is available in **TG-0.2 Overview of Relevant Statistical Standards**.

¶5 **Compound annual growth rate (CAGR)** — measures average annual growth over multiple periods:

$$\text{CAGR} = \left(\frac{X_T}{X_0}\right)^{1/T} - 1$$

¶6 where X_0 is the value at the beginning of the period, X_T is the value at the end, and T is the number of years between them.

DRAFT

Productivity indicators

¶1 Productivity measures the efficiency with which inputs are transformed into outputs. Two measures are particularly relevant for ocean economy analysis[13]:

¶2 **Labour productivity**

$$\text{Labour productivity} = \frac{\text{GVA}}{\text{Employment}}$$

¶3 This can be expressed per person employed, per job, or per hour worked. Labour productivity in ocean industries can be compared to national averages to assess relative efficiency.

¶4 **Capital productivity** (where capital stock data are available)

$$\text{Capital productivity} = \frac{\text{GVA}}{\text{Capital stock}}$$

¶5 Capital stock data for ocean industries are often limited, particularly for industries such as offshore energy and maritime transport where assets are mobile and may be registered in multiple jurisdictions. Where direct capital stock data are unavailable, compilers may estimate capital stocks using the perpetual inventory method, applying asset-specific depreciation rates to historical investment series. The asset valuation methodology described in **TG-3.1 Asset Accounts** provides relevant guidance on produced capital valuation that can be adapted for ocean industries, particularly for vessels, port infrastructure, and offshore installations[14].

¶6 **Multi-factor productivity growth** requires more sophisticated analysis combining labour, capital, and intermediate inputs, typically using growth accounting or index number methods[15].

Ocean economy contribution to GDP growth

¶1 A particularly policy-relevant indicator is the contribution of the ocean economy to overall GDP growth[16]:

¶2

$$\text{Contribution to GDP growth} = \frac{\Delta\text{Ocean GVA}}{\text{GDP}_{t-1}} \times 100$$

¶3 This measures the percentage point contribution of ocean economy growth to national GDP growth. This indicator is directly relevant for the budget justifications addressed in **TG-1.1 OA and National Budget Processes** and for demonstrating the economic importance of ocean management investment.

3.4 Net Ocean GVA

¶1 Gross measures of ocean economy value added do not account for the depletion of the marine natural resources on which many ocean industries depend. The SNA 2025 treats depletion of non-produced natural resources as a cost of production (SNA 2025 Chapter 13, para 13.26; see also the net value added formula in Chapter 15, para 15.137), and **TG-1.1** Section 3.1 identifies net domestic product (NDP) as the conceptually preferred measure of economic growth[17]. For the ocean economy, this has particular significance because fisheries, offshore minerals, and other extractive ocean industries draw down natural capital stocks.

¶2 **Net ocean GVA** is defined as:

DRAFT

¶3

$$\text{Net ocean GVA} = \text{Gross ocean GVA} - \text{Depletion of marine natural resources}$$

¶4 Depletion of marine natural resources includes:

- ¶5 **Depletion of fish stocks** – the decline in the economic value of fish stock assets due to harvesting in excess of natural regeneration. Estimation methods are described in **TG-3.1 Asset Accounts**, drawing on stock assessment data from **TG-6.7 Fisheries Accounting: Integrating Stock Assessment**.
- ¶6 **Depletion of seabed minerals** – the decline in the economic value of offshore mineral and hydrocarbon reserves due to extraction. Valuation follows the SNA 2025 treatment of subsoil assets (Chapter 15, rows 22–23 of the Use Table).

¶7 Where depletion estimates are available, compilers should present both gross and net measures of ocean GVA side by side. The difference between gross and net ocean GVA reveals the extent to which the ocean economy's recorded economic contribution depends on the drawdown of natural capital. A large and growing gap between gross and net ocean GVA signals unsustainable resource use patterns that should inform policy deliberations under medium-term expenditure frameworks (**TG-1.1** Section 3.4). In the Country A illustration (Table 3.1), if fish stock depletion is estimated at USD 35 million and offshore mineral depletion at USD 60 million per year, net ocean GVA would be USD 1,655 million—approximately 5.4 per cent below the gross figure of USD 1,750 million.

3.5 Employment Structure

¶1 Employment structure indicators characterise the labour market dimensions of the ocean economy, informing policies on education, training, migration, and social protection.

Employment levels and shares

¶1 **Ocean economy employment share**

$$\text{Employment share} = \frac{\text{Ocean employment}}{\text{Total national employment}} \times 100$$

¶2 **Industry-specific employment** – employment in each ocean industry, enabling analysis of which sectors are most labour-intensive[18].

Employment characteristics

¶1 Beyond aggregate employment, structural analysis should capture employment quality and composition[19]:

¶2 **Status in employment**

- ¶3 Employees (wage and salary workers)
- ¶4 Employers
- ¶5 Own-account workers
- ¶6 Contributing family workers

¶7 **Working time**

- ¶8 Full-time versus part-time employment
- ¶9 Average hours worked
- ¶10 Seasonal patterns in employment

¶11 **Demographic characteristics**

DRAFT

- ¶12 Gender composition (share of women in ocean employment)
- ¶13 Age structure
- ¶14 Educational attainment
- ¶15 Nationality (share of migrant workers)

¶16 **Decent work indicators** following the ILO Decent Work Measurement Framework[20]:

- ¶17 Share of formal versus informal employment
- ¶18 Wage levels relative to national average
- ¶19 Working conditions indicators
- ¶20 Social protection coverage

¶21 The distinction between formal and informal employment is particularly relevant for small-scale fisheries, where employment is often characterised by own-account work, seasonal or part-time engagement, and limited coverage by labour regulations or social protection schemes. Measuring employment in small-scale fisheries presents methodological challenges: workers may not appear in business registers, labour force surveys may undercount seasonal or part-time fishing activity, and the boundary between subsistence fishing and commercial fishing can be difficult to establish. Compilers should consider supplementing standard data sources with fisheries census data, community-based surveys, and vessel registry information. Employment patterns in aquaculture, including the prevalence of informal and seasonal work in coastal communities, are addressed in **TG-3.9 Aquaculture**. The connection between employment data and stock management is discussed in **TG-6.7 Fisheries Accounting: Integrating Stock Assessment**.

¶22 Table 3.2 presents employment structure indicators for Country A, populated with synthetic data reflecting typical patterns observed in medium-income coastal states.

¶23 **Table 3.2: Ocean economy employment structure (Country A, illustrative)**

Indicator	Marine fishing	Aquaculture	Maritime transport	Offshore energy	Shipbuilding	Coastal tourism	T o
Persons employed	32,000	22,000	36,000	24,000	18,000	153,000	3
FTE employment	24,000	18,000	35,000	24,000	17,500	120,000	2
Share female (%)	15	35	12	15	8	55	3
Share youth <25 (%)	22	28	15	10	18	35	2
Share informal (%)	60	40	5	2	5	30	2
Avg. wage (USD/month)	280	320	750	2,800	680	350	4
Productivity index (economy = 100)	55	55	180	350	120	65	1

¶24 *The Total ocean column covers all seven industries in Table 3.1. Marine renewable energy (6,000 persons) and other ocean industries (9,000 persons) are not shown as columns, so the six columns sum to 285,000 persons and 238,500 FTE; the remaining 15,000 persons and 11,500 FTE belong to those two industries. Marine fishing and aquaculture together make up marine living resources in Table 3.1 (54,000 persons).*

¶25 Marine fishing exhibits the highest informality rate (60 per cent) and the lowest female participation (15 per cent), consistent with the artisanal and small-scale character of much of the sector. Coastal tourism is the largest employer by a substantial margin (153,000 persons, or 51 per cent of ocean employment), but it has the highest rate of part-time and seasonal work, as reflected in the gap between persons employed and FTE employment. Offshore energy employs relatively few workers (24,000 persons) but generates the highest wages and highest productivity index (350), reflecting the capital-intensive nature of offshore oil, gas, and wind operations. These patterns

DRAFT

inform workforce development policies, gender mainstreaming strategies, and social protection design for ocean-dependent communities.

Spatial distribution of employment

¶1 Spatial analysis of ocean employment reveals regional concentration, coastal community dependence, and commuting patterns between coastal and inland areas. This spatial dimension connects to livelihood dependency analysis in **TG-2.3 Livelihood Dependencies**.

3.6 Trade and Investment Indicators

¶1 Trade and investment indicators reveal the ocean economy's external orientation and its capacity for growth through capital accumulation.

Trade indicators

¶1 **Ocean economy exports**

$$\text{Export share} = \frac{\text{Exports of ocean products}}{\text{Total national exports}} \times 100$$

¶2 Ocean exports include:

- ¶3 Fish and fishery products
- ¶4 Maritime transport services
- ¶5 Offshore oil and gas (where applicable)
- ¶6 Cruise and marine tourism receipts
- ¶7 Ship repair services

¶8 **Ocean economy imports** – imports of ocean-characteristic products, including:

- ¶9 Fishing vessels and equipment
- ¶10 Maritime transport services (freight payments)
- ¶11 Offshore drilling equipment
- ¶12 Imported fish for processing

¶13 **Trade balance for ocean economy**

$$\text{Ocean trade balance} = \text{Ocean exports} - \text{Ocean imports}$$

¶14 **Revealed comparative advantage** – indicates whether a country specialises in ocean products relative to its overall trade pattern [21]:

$$\text{RCA}_i = \frac{(X_i / X)}{(X_i^{world} / X^{world})}$$

¶15 where X_i is exports of ocean product i, X is total exports, X_i^{world} is world exports of ocean product i, and X^{world} is total world exports. An RCA > 1 indicates comparative advantage.

¶16 Maritime transport services trade requires careful treatment due to the distinction between resident and non-resident operators. The spatial treatment of economic activities within the Exclusive Economic Zone is addressed in **TG-3.3** Section 3.1. The Balance of Payments Manual (BPM6; BPM7, forthcoming) provides detailed guidance on recording maritime transport services in the current account, including the allocation of freight charges between importing and exporting economies and the treatment of services provided by non-resident carriers [22]. Compilers should

DRAFT

ensure that trade in maritime transport services is recorded consistently between the ocean economy accounts and the balance of payments.

Investment indicators

¶1 **Gross fixed capital formation (GFCF) in ocean industries**

¶2 Ocean economy investment includes:

- ¶3 Vessels (fishing boats, cargo ships, cruise ships)
- ¶4 Port infrastructure (harbours, terminals, cargo handling equipment)
- ¶5 Offshore platforms and installations
- ¶6 Aquaculture facilities
- ¶7 Coastal tourism infrastructure

¶8 **Investment rate**

$$\text{Investment rate} = \frac{\text{Ocean GFCF}}{\text{Ocean GVA}} \times 100$$

¶9 **Investment share**

$$\text{Investment share} = \frac{\text{Ocean GFCF}}{\text{Total national GFCF}} \times 100$$

¶10 This reveals the ocean economy's share of national capital formation.

¶11 **Foreign direct investment (FDI) in ocean sectors** – where data permit, the stock and flow of FDI in ocean industries provides insight into external capital participation. This may be particularly significant in offshore energy, maritime transport, and port operations [23]. FDI data by detailed industry are often limited and may be subject to confidentiality constraints where few enterprises operate in a given industry. Where direct FDI data are unavailable, compilers may use alternative approaches such as ownership information from business registers, investment project tracking databases, or qualitative assessments based on known foreign ownership in key ocean industries. Detailed treatment of investment analysis for the ocean economy is provided in **TG-2.6 Ocean Investment**.

Sustainable ocean finance

¶1 Beyond conventional GFCF, the investment dimension of the ocean economy increasingly includes **sustainable ocean finance** instruments such as blue bonds, blue loans, and blue equity investments. These instruments channel capital towards ocean-related activities that meet defined environmental sustainability criteria. Whilst sustainable finance flows are not recorded as GFCF in the national accounts (they represent financial transactions rather than acquisition of produced assets), their scale and growth constitute an important structural characteristic of the ocean economy's financing landscape. The methodology for measuring sustainable ocean finance, including classification criteria, data sources, and indicator definitions, is addressed in **TG-2.6 Ocean Investment** Section 3.4.

¶2 Table 3.3 presents trade and investment indicators for Country A.

¶3 **Table 3.3: Ocean economy trade and investment (Country A, illustrative)**

Indicator	Value (million USD)	Share of national total (%)
Ocean economy exports	620	5.2
- Fish and fishery products	215	1.8

DRAFT

Indicator	Value (million USD)	Share of national total (%)
- Maritime transport services	240	2.0
- Other ocean products	165	1.4
Ocean economy imports	480	3.8
Ocean trade balance	140	–
Ocean GFCF	380	3.5
- Vessels	95	–
- Port infrastructure	110	–
- Offshore installations	125	–
- Other ocean assets	50	–
FDI stock in ocean industries	1,200	4.8

Government expenditure on ocean-related functions

¶1 Government expenditure on ocean-related activities can be identified using the Classification of the Functions of Government (COFOG)[24]. Table 3.4 maps specific COFOG classes to ocean-related government functions, adapted from the SF-MST approach to identifying tourism-related government functions (SF-MST Table 3.9)[25].

¶2 **Table 3.4: COFOG classes relevant to ocean economy functions**

COFOG Division	COFOG Class	Ocean-related function
01 General public services	01.3 General services	Maritime administration, hydrographic services
03 Public order and safety	03.1 Police services	Coast guard, maritime enforcement
04 Economic affairs	04.2 Agriculture, forestry, fishing	Fisheries management, aquaculture support
04 Economic affairs	04.5 Transport	Maritime transport infrastructure, port development
04 Economic affairs	04.7 Other industries	Marine biotechnology, ocean industry support
05 Environmental protection	05.1 Waste management	Marine pollution remediation
05 Environmental protection	05.2 Wastewater management	Coastal wastewater treatment
05 Environmental protection	05.4 Protection of biodiversity	Marine protected area management
06 Housing and community	06.3 Water supply	Desalination
07 Health	07.4 Public health services	Marine food safety
08 Recreation, culture	08.1 Recreational and sporting	Coastal recreation infrastructure
09 Education	09.4 Tertiary education	Maritime education and training
10 Social protection	10.5 Unemployment	Fisheries worker adjustment programmes

DRAFT

¶3 This mapping supports analysis of public investment in ocean management addressed in **TG-1.1 OA and National Budget Processes**.

3.7 Compilation Procedure

¶1 The procedure below is adapted from the SNA 2025 treatment of supply and use tables (Chapter 15, paras 15.9, 15.130–15.139) and draws on the analogous approach developed for tourism in the SF-MST (paras 2.30–2.31, 3.27–3.28)[26].

Step-by-step compilation

¶1 **Steps 1–5 are TG-3.3's.** Identifying ocean industries through the ISIC concordance, extracting the sub-matrices from the balanced national SUTs, determining the ocean ratio for each partially

ocean-related industry, computing Ocean Economy Direct GVA and adjusting for taxes less subsidies on products to reach Ocean Economy Direct GDP are all specified in **TG-3.3 Economic Activity Relevant to the Ocean** Sections 3.4 and 3.5. They are not restated here.

¶2 What a compiler needs to check before deriving the indicators below is that the extract carries: GVA and employment **by industry** rather than as an ocean-economy total, the **ocean ratio and its estimation level** recorded per industry, and a consistent **employment measure** across numerator and denominator. Composition, productivity and structure indicators all require the disaggregation; the ratios cannot be recovered from a single total.

¶3 **Step 6: Derive indicators from the ocean economy SUT extract.** Using the ocean economy sub-matrices and the ocean economy ratios, compute the full set of structural indicators described in Sections 3.2 through 3.6 of this Circular: sector composition indicators (GVA shares, employment shares, HHI), growth and productivity indicators, net GVA, employment structure, and trade and investment indicators.

Data pipeline

¶1 Raw data are collected through surveys (**TG-4.2**) and administrative records (**TG-4.3**), harmonised (**TG-4.6**), and compiled into ocean economy thematic accounts (**TG-3.3**). The indicator formulas in this Circular are then applied to produce structural indicators, which are formatted for policy application in national budget processes (**TG-1.1**) and international reporting (**TG-2.10**).

3.8 Compilation Considerations

Data sources

¶1 Key data sources include[27]:

- ¶2 National accounts (supply and use tables, production accounts)
- ¶3 Business surveys and censuses
- ¶4 Labour force surveys
- ¶5 Trade statistics
- ¶6 Administrative records (vessel registries, port authorities, fishing licences)

¶7 Detailed guidance on the utilisation of these data sources is provided in **TG-4.2 Survey Methods for Ocean Economic Activity**, **TG-4.3 Administrative Data Sources**, and **TG-4.6 Data Harmonisation and Interoperability**.

Informal economy and indicator reliability

¶1 Structural indicators may understate the full extent of the ocean economy where informal economic activities are significant. Small-scale fisheries, artisanal aquaculture, informal coastal tourism services, and subsistence marine harvesting are often inadequately captured by standard business surveys and national accounts. In countries where informal activities constitute a substantial share of ocean-related production and employment, the indicators derived from formal data sources may present an incomplete picture of the ocean economy's true size and structure. Compilers should document the estimated coverage of formal data sources relative to the full ocean economy, identify sectors where informal activity is likely to be most significant, and consider the supplementary estimation methods described in **TG-4.2** and **TG-4.3** for improving coverage of informal activities. Reporting these coverage limitations alongside the indicators lets users interpret aggregate statistics with appropriate caution.

Quality indicators

¶1 Compilers should document:

- ¶2 Coverage (which industries and products are included)

DRAFT

- ¶3 Methods for estimating ocean-related shares of mixed industries
- ¶4 Frequency of data collection and time lags
- ¶5 Accuracy estimates and confidence intervals where available

¶6 Quality assurance guidance is provided in **TG-0.7 Quality Assurance Principles**.

¶7 **Publication scope norm.** Compilers should publish only what their supply and use tables can support. The starting set is the core four indicators — gross output, GVA, employment, and GFCF — compiled directly from the SUTs; trade in ocean-characteristic products is added only where it can be balanced against the SUTs. Extension to additional indicators is appropriate only after supplementary sources have been properly reconciled with national accounts data. Where partials are used, the underlying data sources and allocation rules should be published alongside indicator results[8].

¶8 **Metadata requirements.** Ocean accounts metadata should document at minimum: sector and industry coverage, the economic concepts applied (including whether a Type 1 or Type 2 approach was used), time period, geographic definition and inland boundary decisions, industrial classification system, data collection method per industry (survey, administrative data, or expert judgement), and any confidentiality suppressions applied. Because ocean account scope and geographic boundary definitions legitimately differ across countries, metadata is the primary mechanism enabling valid cross-country comparisons[6].

Comparability considerations

¶1 For time series analysis and international comparison:

- ¶2 Use consistent industry and product classifications
- ¶3 Apply consistent valuation principles (basic prices versus purchasers' prices)
- ¶4 Document changes in methodology that affect comparability
- ¶5 Use appropriate exchange rates for international comparison

¶6 The standing international comparators — the European Commission's annual *EU Blue Economy Report* and the OECD's ocean economy measurement work — are described in **TG-1.0** Section 3.6, and the reader-side checklist for interrogating a published figure is TG-1.0 Section 3.7.

DRAFT

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

5. References

1. ¶1 United Nations et al. (2025). *System of National Accounts 2025*. New York: United Nations. ST/ESA/STAT/SER.F/2/Rev.6. Chapters 7 (Production account), 15 (Supply and use tables), and 18 (Measuring prices, volumes and productivity).
2. ¶2 World Tourism Organization (2024). *Statistical Framework for Measuring the Sustainability of Tourism (SF-MST)*. Final Draft, February 2024. Chapter 3 on Measuring the economic dimension. See particularly Section 3.3 on "Measuring the economic structure and performance of tourism industries."
3. ¶3 United Nations (2021). *System of Environmental-Economic Accounting - Ecosystem Accounting*. Statistical Papers Series F No. 124. New York: United Nations. Chapter 13 on accounting for specific environmental themes, including the ocean economy thematic accounting component.
4. ¶4 This four-dimensional framework draws on the analytical approaches described in OECD (2016). *The Ocean Economy in 2030*. Paris: OECD Publishing.
5. ¶5 World Tourism Organization (2024). *SF-MST*, Section 2.5 on Measuring the sustainability of tourism at sub-national levels. The destination-level measurement approaches described in Section 3.7 are directly adaptable for coastal and marine economic zone analysis.
6. ¶6 Colgan, C.S. (2022). *A Guide to Creating Core Ocean GDP Accounts*. Global Ocean Accounts Partnership. Available at: https://www.oceanaccounts.org/a-guide-to-creating-core-ocean-gdp-accounts/

(https://www.oceanaccounts.org/a-guide-to-creating-core-ocean-gdp-accounts/)

7. ¶7 United Nations et al. (2025). *System of National Accounts 2025*, Chapter 15 on Supply and use tables provides the methodological foundation for deriving structural indicators.
8. ¶8 Global Ocean Accounts Partnership (2025). *Valuing the Ocean Economy: Lessons from Earlier Adopters*. GOAP Publication. Available at: https://oceanaccounts.org/publications/valuing-the-ocean-economy-lessons-from-earlier-adopters/ (https://oceanaccounts.org/publications/valuing-the-ocean-economy-lessons-from-earlier-adopters/)
9. ¶9 United Nations (2008). *International Standard Industrial Classification of All Economic Activities (ISIC), Revision 4*. Statistical Papers Series M No. 4/Rev.4. New York: United Nations.
0. ¶10 These indicators follow standard practice in economic structure analysis. See Eurostat (2013). *European System of Accounts (ESA 2010)*. Luxembourg: Publications Office of the European Union.
1. ¶11 UNWTO and UNSD (2008). *International Recommendations for Tourism Statistics 2008*, Chapter 7 provides guidance on employment measures applicable to sector thematic accounts.
2. ¶12 United Nations et al. (2025). *System of National Accounts 2025*, Chapter 18 on Measuring prices, volumes and productivity provides guidance on deflation methods.
3. ¶13 OECD (2001). *Measuring Productivity: OECD Manual*. Paris: OECD Publishing. Provides comprehensive guidance on productivity measurement applicable to sectoral analysis.
4. ¶14 The perpetual inventory method is described in OECD (2009). *Measuring Capital: OECD Manual*. 2nd edition. Paris: OECD Publishing. For ocean-industry-specific asset valuation, see also **TG-3.1 Asset Accounts**.
5. ¶15 For multi-factor productivity analysis, see Jorgenson, D.W., F.M. Gollop, and B.M. Fraumeni (1987). *Productivity and U.S. Economic Growth*. Cambridge: Harvard University Press.
6. ¶16 This decomposition follows standard growth accounting practice. See SNA 2025 Chapter 18 for methodological details.
7. ¶17 United Nations et al. (2025). *System of National Accounts 2025*, Chapter 15, para 15.137: "Gross value added minus depreciation of fixed assets minus depletion of non-produced natural resources equals net value added." See also **TG-1.1** Section 3.1 on the policy rationale for net measures.
8. ¶18 Industry-level employment data follow ISIC classification, consistent with the industry classification in **TG-3.3 Economic Activity Relevant to the Ocean**.
9. ¶19 ILO (2018). *Guidelines concerning statistics of international labour migration*. 20th International Conference of Labour Statisticians. Geneva: ILO.
0. ¶20 ILO (2013). *Decent Work Indicators: Guidelines for Producers and Users of Statistical and Legal Framework Indicators*. 2nd edition. Geneva: ILO.
1. ¶21 Balassa, B. (1965). "Trade Liberalisation and 'Revealed' Comparative Advantage." *The Manchester School* 33(2): 99-123.
2. ¶22 IMF (2009). *Balance of Payments and International Investment Position Manual*. 6th edition (BPM6). Washington, D.C.: International Monetary Fund. Chapter 10 on goods and services, particularly Section C on transport services.
3. ¶23 UNCTAD (2022). *World Investment Report 2022*. Geneva: United Nations Conference on Trade and Development. Chapter on sustainable blue economy investment.
4. ¶24 United Nations (2000). *Classification of the Functions of Government (COFOG)*. In *Classifications of Expenditure According to Purpose*. Statistical Papers Series M No. 84. New York: United Nations.
5. ¶25 World Tourism Organization (2024). *SF-MST*, Table 3.9 on "Tourism related Functions of Government – COFOG classes." The mapping in Table 3.4 adapts this approach for ocean economy functions.
6. ¶26 The compilation procedure adapts the SNA 2025 supply and use table compilation methodology (Chapter 15, paras 15.9, 15.130–15.139) and the tourism ratio approach from the SF-MST (paras 2.30–2.31, 3.27–3.28). For the ocean economy context, see also **TG-3.3** Section 3.4 on ocean economy SUT compilation.
7. ¶27 Data source guidance aligns with **TG-4.2 Survey Methods for Ocean Economic Activity**, **TG-4.3 Administrative Data Sources**, and **TG-4.6 Data Harmonisation and Interoperability** in the Ocean Accounts Technical Guidance series.

DRAFT

Ocean-related Investment

Provides guidance on compiling indicators of ocean-related investment within the Ocean Accounts framework.

Version 0.7.2 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

OUTCOME

This Circular provides guidance on compiling indicators of ocean-related investment within the Ocean Accounts framework. Understanding the scale, composition, and trends of ocean-related investment enables policymakers to assess whether sufficient resources are being directed towards sustainable ocean development and conservation, including the targets set under SDG 14.7 (increasing economic benefits from the sustainable use of marine resources) and SDG 14.5 (conserving at least 10 per cent of coastal and marine areas).

Upon completing this Circular, readers will understand how to measure gross fixed capital formation (GFCF) in ocean industries using thematic and extended accounting principles from the System of National Accounts, compile indicators of public and private ocean investment disaggregated by sector and purpose, track sustainable ocean finance instruments including blue bonds and ESG-classified marine investments, and develop investment tracking methodologies that integrate physical and monetary data. Decision use cases for these indicators include tracking the effectiveness of blue bond proceeds in achieving marine conservation targets, measuring ocean-related GFCF as a share of national capital formation to inform infrastructure planning, and aligning investment reporting with TNFD and IFRS sustainability disclosure frameworks. The guidance supports the compilation of investment indicators consistent with SNA 2025 concepts that can be linked to TG-0.1 General Introduction, TG-0.2 Standards Overview, and the economic activity accounts in TG-3.3 Economic Activity Relevant to the Ocean.

Investment indicators derived from this guidance support analysis of ocean economy development pathways (TG-2.5 Ocean Economy Structure), sustainable finance monitoring (TG-1.7 OA and Multilateral Development Finance and TG-1.8 OA and Project-Level Finance), and resource efficiency assessment (TG-2.11 Resource Efficiency).

DRAFT

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 3
3.1 Ocean Investment Framework 3
3.2 Public Investment Indicators 5
3.3 Private Investment Indicators 7
3.4 Sustainable Ocean Finance Indicators 9
3.5 Investment Tracking Methodology 12
4. Acknowledgements 17
5. References and Further Reading 17
Footnotes 18

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Ocean-related Investment (2026) (GOAP Technical Guidance on Ocean Accounting, TG-2.6, v0.7.2). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-2/2-6-ocean-investment/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

1. Outcome

¶1 This Circular provides guidance on compiling indicators of ocean-related investment within the Ocean Accounts framework. Understanding the scale, composition, and trends of ocean-related investment enables policymakers to assess whether sufficient resources are being directed towards sustainable ocean development and conservation, including the targets set under SDG 14.7 (increasing economic benefits from the sustainable use of marine resources) and SDG 14.5 (conserving at least 10 per cent of coastal and marine areas).

¶2 Upon completing this Circular, readers will understand how to measure gross fixed capital formation (GFCF) in ocean industries using thematic and extended accounting principles from the System of National Accounts[1], compile indicators of public and private ocean investment disaggregated by sector and purpose, track sustainable ocean finance instruments including blue bonds and ESG-classified marine investments, and develop investment tracking methodologies that integrate physical and monetary data. Decision use cases for these indicators include tracking the effectiveness of blue bond proceeds in achieving marine conservation targets, measuring ocean-related GFCF as a share of national capital formation to inform infrastructure planning, and aligning investment reporting with TNFD and IFRS sustainability disclosure frameworks. The guidance supports the compilation of investment indicators consistent with SNA 2025 concepts that can be linked to **TG-0.1 General Introduction**, **TG-0.2 Standards Overview**, and the economic activity accounts in **TG-3.3 Economic Activity Relevant to the Ocean**.

¶3 Investment indicators derived from this guidance support analysis of ocean economy development pathways (**TG-2.5 Ocean Economy Structure**), sustainable finance monitoring (**TG-1.7 OA and Multilateral Development Finance** and **TG-1.8 OA and Project-Level Finance**), and resource efficiency assessment (**TG-2.11 Resource Efficiency**).

DRAFT

2. Requirements

¶1 This Circular requires familiarity with:

- ¶2 **TG-0.1 General Introduction to Ocean Accounts** — for the conceptual framework and key components of Ocean Accounts
- ¶3 **TG-0.2 Standards Overview** — for the international statistical standards underpinning ocean accounting, including SNA 2025, SEEA, and classification systems
- ¶4 **TG-3.3 Economic Activity Relevant to the Ocean** — for the ocean economy thematic and extended accounting framework, industry classifications, and supply and use table structures that provide the foundation for investment measurement

3. Guidance Material

¶1 Investment in the ocean economy encompasses the acquisition of fixed assets by enterprises and government for the production of ocean-related goods and services, as well as targeted expenditure on marine environmental protection and ecosystem restoration. This Circular applies the GFCF framework from the System of National Accounts, supplemented by functional classifications for environmental expenditure and emerging standards for sustainable finance reporting.

3.1 Ocean Investment Framework

¶1 Investment in the ocean context can be organised into three conceptual categories that reflect different motivations, sources, and measurement approaches. This three-category framework provides a useful analytical structure but is not formally standardised in the SNA or SEEA. Countries

may adapt these categories based on national policy priorities, provided that classification choices are documented to support transparency and comparability across compilations.

Where the classification rules are specified

¶1 Four classification decisions govern what an ocean investment compilation may count, and all four are specified in **TG-3.3 Economic Activity Relevant to the Ocean** Section 3.6: the basic/intermediate/extended **scope tiers**; the **capitalisation decision tree** for restoration expenditure, which determines whether mangrove planting or reef restoration is GFCF or current expenditure; **residence and economic ownership** for vessels and offshore installations, including the flags-of-convenience and ABNJ cases; and the **GFCF/EPEA boundary rule** that prevents coastal protection structures being counted twice.

¶2 Two of these bear directly on how the indicators below should be read. A compilation at basic tier should not be presented as exhaustive of ocean-related investment. And the scope tiers are orthogonal to the data-maturity pathway in Section 3.5 (Foundational, Developing, Advanced): the first says what to measure, the second what a compiler can produce from available data. A country at an early data-maturity stage may still target extended scope, and conflating the two understates what a compilation is aiming at.

Ocean Investment Classification Table

¶1 Table 1 provides an overview of the principal types of ocean-related investment, their treatment in the SNA framework, illustrative ocean examples, and typical data sources for compilation.

¶2 **Table 1: Ocean Investment Classification**

Investment Type	SNA Treatment	Ocean Examples	Data Source
Private GFCF	Produced assets	Vessels, processing facilities	Business surveys
Government GFCF	Public infrastructure	Ports, coastal protection	Government finance
FDI	Capital flows	Offshore platforms, hotels	Balance of payments
R&D investment	Intellectual property	Marine research	R&D surveys
Restoration	Varies by nature of expenditure (apply decision tree above)	Mangrove planting, reef restoration	Project records

DRAFT

Relationship to national accounts

¶1 Ocean investment indicators are derived from the broader national accounts framework and should be consistent with national totals. The ocean economy thematic and extended account structure described in **TG-3.3 Economic Activity Relevant to the Ocean** provides the organising framework. Within this structure:

- ¶2 Ocean economy GFCF represents the subset of total national GFCF attributable to ocean industries
- ¶3 Environmental expenditure for ocean protection represents a functional classification of expenditure that may cross multiple industries
- ¶4 Sustainable ocean finance represents a supplementary classification of financial instruments by purpose

Spatial and jurisdictional considerations

¶1 Investment measurement follows the residence principle of the SNA, attributing investment to the economic territory where the producing unit is resident. The governing attribution principle is economic ownership: the residence of the institutional unit that bears the economic risk and

reward associated with the asset, not the flag of registration. For ocean activities, this creates specific considerations:

- ¶2 Investment in vessels operated by a resident economic owner is attributed to the country of residence of that owner, regardless of the flag under which the vessel is registered.
- ¶3 Offshore installations within a country's Exclusive Economic Zone (EEZ) are treated as being within the economic territory of the coastal state.
- ¶4 Investment by non-resident enterprises operating under licence within the EEZ (such as foreign fishing fleets) is attributed to the country of residence of the enterprise.

¶5 **Worked example — flags of convenience.** A vessel legally registered in Country A (an open registry), economically owned by an enterprise resident in Country B, and operated under a bareboat charter to a fishing company resident in Country C, is attributed to Country B for GFCF purposes, as Country B's enterprise bears the economic risk and holds title to the asset. Country A records no GFCF for the vessel. Its open-registry function does not confer economic ownership. For compilers in jurisdictions with large open registries or large beneficial-ownership shipping sectors, this distinction is material. See BPM7 Chapter 4 (Institutional Units and Sectors, Economic Territory, and Residence), paragraphs 4.214-4.220, for the corresponding treatment in external sector statistics.

¶6 The treatment of maritime investments has been clarified in SNA 2025, which provides guidance on the economic ownership of ships and offshore structures [2]. For areas beyond national jurisdiction (ABNJ), the 2025 SNA notes that "where there is interest in organising data about these types of natural capital outside of the scope of the integrated framework of the SNA … the accounting definitions and treatments of the integrated framework of the SNA and the SEEA can be applied" [3]. That approach is relevant for investment in activities spanning EEZ and high seas areas. The entry into force of the BBNJ Agreement on 17 January 2026 may introduce new governance arrangements with implications for statistical treatment of investment in ABNJ. Compilers should monitor developments in this area and consult **TG-6.6 Deep-Sea and ABNJ** for further guidance on accounting for activities in these zones [4].

¶7 **Interim guidance for ABNJ-adjacent investment.** Pending updated guidance from GOAP or the UN Statistics Division on BBNJ-related statistical treatment, compilers preparing 2025 and 2026 ocean accounts should:

1. ¶8 Apply the SNA residence principle as the default rule: investment in ABNJ-related activities (deep-sea mining, high-seas fishing, BBNJ-linked biodiversity offset instruments) is attributed to the economic territory of the investing institutional unit.
2. ¶9 Flag ABNJ-related investment as a separate memorandum item beneath the main ocean investment totals, so that future revision is straightforward when authoritative guidance is issued.
3. ¶10 Retain full documentation of classification decisions (instrument, activity location, residence determination, taxonomy applied) to enable retrospective revision.

3.2 Public Investment Indicators

¶1 Measurement of public investment draws on government finance statistics and the Classification of the Functions of Government (COFOG).

Government GFCF in ocean industries

¶1 Table 3.2.1 below summarises the principal categories of government capital formation in ocean industries.

Category	Examples
Port and harbour infrastructure	Wharves, breakwaters, navigational aids, port terminals.
Coastal protection structures	Sea walls, groynes, beach nourishment works.
Marine research facilities	Oceanographic research stations, research vessels, monitoring infrastructure.

DRAFT

Category	Examples
Fisheries management assets	Patrol vessels, monitoring systems, hatchery facilities.
Maritime safety assets	Lighthouses, coast guard facilities, search and rescue equipment.

¶2 Where government GFCF is recorded by function using COFOG, the following classes are relevant to ocean investment[5]:

- ¶3 COFOG 04.5 – Transport (including maritime transport infrastructure)
- ¶4 COFOG 04.2 – Agriculture, forestry, fishing and hunting (including fisheries management)
- ¶5 COFOG 05.3 – Pollution abatement (including marine pollution control)
- ¶6 COFOG 05.4 – Protection of biodiversity and landscape (including marine conservation)
- ¶7 COFOG 02.1 – Military defence (including naval assets, where separately identifiable)

¶8 **Isolating maritime transport within COFOG 04.5.** The international COFOG standard halts at the 4-digit class level (04.5.2 Water transport), and in most countries COFOG 04.5 as a whole aggregates road, rail, air, and water transport spending. To isolate the maritime component, compilers should triangulate using supplementary administrative sources, including:

- ¶9 Transport ministry project lists and capital programme documentation, filtered for port, harbour, dredging, and navigational projects
- ¶10 Port authority capital accounts and annual reports
- ¶11 Maritime safety authority budgets (lighthouses, coast guard, vessel traffic services)
- ¶12 Where available, national or regional COFOG extensions that disaggregate water transport from inland-waterway, rail, road, and air components (for example, Eurostat national compilation manuals provide such extensions for EU member states)

¶13 There is no UN-issued fourth-level standard disaggregation for maritime transport within COFOG 04.5. Any sub-class breakdown is a national or regional statistical extension and should be documented as such.

¶14 The Statistical Framework for Measuring the Sustainability of Tourism (SF-MST) notes that "government gross fixed capital formation may also be classified using COFOG and hence data for expenditures following the same classes … may be available"[6]. This approach can be adapted for ocean economy measurement. Guidance on integrating government fiscal classifications with ocean accounts is provided in **TG-1.1 Budget Processes**, which addresses COFOG concordances and the mapping of budget line items to ocean economy categories.

Government environmental expenditure for ocean protection

¶1 The SEEA Central Framework's Environmental Protection Expenditure Account (EPEA) can be adapted for marine contexts. Table 3.2.2 below summarises relevant expenditure categories for ocean protection.[7]

Category	Description
Wastewater management	Treatment of coastal and marine wastewater, prevention of marine pollution from land-based sources.
Waste management	Collection and treatment of marine debris, coastal cleanup operations.
Protection of biodiversity and landscapes	Marine protected area management, species conservation, habitat restoration.
Research and development	Marine environmental research, development of ocean-friendly technologies.

¶2 Government environmental protection expenditure encompasses both current expenditure (operational costs of protection activities) and capital expenditure (investment in environmental protection infrastructure and equipment). The SEEA defines total national expenditure on environmen-

DRAFT

tal protection as including final consumption, intermediate consumption, and gross fixed capital formation on all environmental protection goods and services, plus capital formation for characteristic activities, plus relevant transfers[8].

Indicator examples

¶1 From the public investment data, the following indicators can be derived:

Indicator	Description	Unit
Government GFCF in ocean industries	Total government capital formation in ocean-related assets	Currency units
Government ocean GFCF as share of total government GFCF	Relative intensity of ocean investment	Percentage
Government expenditure on marine environmental protection	Current and capital expenditure for marine protection purposes	Currency units
Government marine protection expenditure per km of coastline	Investment intensity relative to coastal extent	Currency units per km
Government marine protection expenditure per km² of EEZ	Investment intensity relative to marine territory	Currency units per km²
Government investment in marine protected area management	Capital formation specifically for MPA infrastructure	Currency units

3.3 Private Investment Indicators

¶1 Measurement of private investment draws on business survey data, administrative records, and estimation techniques that identify the ocean-related component of broader industry investment.

Corporate GFCF in ocean industries

¶1 Following the industry classification approach in **TG-3.3 Economic Activity Relevant to the Ocean**, private sector GFCF can be compiled for core ocean industries and ocean-related industries.

¶2 **Core ocean industries** where investment is entirely ocean-related:

- ¶3 Division 03 (Fishing and Aquaculture) — vessels, nets, aquaculture pens, processing equipment
- ¶4 Division 50 (Water Transport) — ships, port equipment, navigation systems
- ¶5 Class 0610/0620 (Offshore Petroleum) — platforms, drilling equipment, pipelines
- ¶6 Offshore renewable energy — wind turbines, tidal installations, foundations

¶7 **Ocean-related industries** where the ocean component of investment must be estimated:

- ¶8 Class 1020 (Fish Processing) — processing plants and equipment for marine products
- ¶9 Class 3011/3012 (Shipbuilding) — shipyards, construction equipment, dry docks
- ¶10 Class 5222 (Port Services) — cargo handling equipment, terminal facilities
- ¶11 Coastal tourism — accommodation facilities with marine access, marine recreation equipment

¶12 For industries only partially related to the ocean, the methods for determining ocean-related shares described in **TG-3.3 Economic Activity Relevant to the Ocean** (specifically, the supply-use approach for estimating ocean ratios) can be applied to investment data. Important methodological caveats on applying GVA-derived ocean ratios to GFCF are set out in Section 3.5 Step 3.

Types of ocean-related assets

¶1 For ocean industries, relevant fixed asset categories include[9]:

DRAFT

Fixed asset category	Ocean-relevant examples
Dwellings and buildings	Coastal commercial buildings, port facilities, processing plants.
Other structures	Breakwaters, offshore platforms, aquaculture structures.
Transport equipment	Vessels of all types, offshore supply vessels, submersibles.
Machinery and equipment	Fishing gear, processing machinery, navigation equipment.
Intellectual property products	Marine research and development, software for ocean applications.

¶2 **Inventories** (not GFCF but relevant for ocean economy measurement):

- ¶3 Work-in-progress (fish in aquaculture pens approaching harvest)
- ¶4 Finished goods inventories (processed seafood products)

¶5 Table 2 provides an illustrative asset breakdown for the aquaculture sector to demonstrate how investment can be disaggregated by asset type within a single ocean industry. This template can be adapted by compilers for other ocean sectors.

¶6 **Table 2: Illustrative Asset Breakdown – Aquaculture Sector Investment**

Asset Type	Examples	Typical Share[10]
Other structures	Ponds, cages, pens, raceways	30-50%
Machinery and equipment	Feeding systems, aeration, grading	15-25%
Transport equipment	Harvest boats, feed delivery vessels	5-15%
Buildings	Hatcheries, processing sheds, cold storage	10-20%
Intellectual property	Breeding programmes, aquaculture R&D	5-10%

> *WARNING – do not use as default imputations. The ranges in Table 2 are presented for orientation only. They reflect cross-country variability across species, production systems, and stages of sector development, and must not be used as default imputations where national data are absent. Compilers without national survey or registry data on aquaculture asset composition should report the disaggregation as "not available" rather than substituting these ranges, and should source actual shares from national capital expenditure surveys, aquaculture census data, or sector-specific appraisal records before publication.*

DRAFT

Investment in environmental technologies

¶1 Corporate investment in environmental protection technologies represents a specific component of ocean-related GFCF. Such investment is sometimes called "end-of-pipe" or "integrated". The SEEA distinguishes[11]:

- ¶2 **End-of-pipe investments** – technologies that treat or control emissions and discharges after they are generated (e.g., ballast water treatment systems, exhaust gas cleaning systems)
- ¶3 **Integrated investments** – modifications to production processes that prevent or reduce pollution at source (e.g., fuel-efficient vessel designs, sustainable aquaculture systems)

¶4 These investments contribute to both ocean economy development and marine environmental protection. They sit at the nexus of the economic and environmental dimensions of ocean accounting. The SEEA notes that "estimating the expenditure on integrated investments requires consideration of the general concerns in respect of measuring adapted goods" including the challenge of defining reference technologies against which "cleaner" alternatives can be compared[12].

Indicator examples

¶2 From the private investment data, the following indicators can be derived:

Indicator	Description	Unit
Private GFCF in ocean industries	Total corporate capital formation in ocean-related assets	Currency units
Private ocean GFCF as share of total private GFCF	Relative intensity of ocean investment	Percentage
Ocean industry GFCF by sector	Investment disaggregated by fishing, shipping, offshore energy, etc.	Currency units
Ocean GFCF as share of ocean GVA	Investment intensity relative to sector output	Percentage
Environmental technology investment in ocean industries	GFCF in pollution control and cleaner technologies	Currency units
Shipbuilding GFCF	Investment in vessel construction capacity	Currency units

3.4 Sustainable Ocean Finance Indicators

¶1 Sustainable ocean finance (often termed "blue finance") comprises financial instruments where proceeds are directed to activities that sustain or improve marine and coastal environmental conditions[13]. This includes:

¶2 **Blue debt securities — use-of-proceeds instruments** — debt where proceeds are earmarked for ocean-positive activities:

- ¶3 Blue bonds issued by sovereigns, corporates, or development banks
- ¶4 Green bonds with marine-focused use of proceeds

¶5 **Blue debt securities — performance-linked instruments (extended scope)** — debt whose classification depends on the issuer's stated ocean-related performance targets rather than the use of capital raised:

- ¶6 Sustainability-linked bonds (SLBs) with ocean-related key performance indicators

¶7 **Blue loans** — loans where a significant share of the debtor's activities improve marine environmental conditions:

- ¶8 Loans to sustainable fisheries enterprises
- ¶9 Loans for marine renewable energy projects
- ¶10 Loans for coastal ecosystem restoration

¶11 **Blue equity** — equity investments in enterprises whose activities predominantly improve marine conditions:

- ¶12 Investment in sustainable aquaculture
- ¶13 Investment in ocean cleanup technologies
- ¶14 Investment in marine biotechnology

¶15 The SNA recommends that sustainable finance be compiled as supplementary "of which" items within the financial accounts. That treatment allows tracking without disrupting the standard accounts structure[14]. The classification follows Table 35.3 of SNA 2025, which distinguishes debt securities, loans, equity, and investment fund shares/units, with "of which" items for ESG and green classifications.

¶16 **Distinguishing use-of-proceeds from performance-linked instruments.** Blue bonds and earmarked blue loans direct identified capital to ocean-positive activities. Sustainability-linked bonds (SLBs), by contrast, have general use of proceeds with coupon step-ups (or other financial features) tied to the issuer meeting defined KPIs. An SLB with an ocean-related KPI signals issuer commitment but does not direct capital to ocean activities. If the KPI is missed, the coupon increases but the proceeds remain unaffected. For this reason:

- ¶17 Use-of-proceeds instruments are recorded in the basic blue-finance scope.

DRAFT

- ¶18 SLBs with ocean KPIs are recorded as an extended scope memorandum item, distinct from use-of-proceeds totals, and labelled as reflecting stated issuer commitment rather than confirmed capital allocation. See the ICMA Sustainability-Linked Bond Principles for the conceptual distinction.

Minimum classification protocol for blue finance instruments

¶1 In the absence of a single agreed international blue finance taxonomy, compilers should apply the following three-tier minimum classification protocol so that figures are comparable across countries and over time even before harmonisation:

1. ¶2 **Reported blue finance (self-labelled)** — record all instruments self-labelled by the issuer as "blue" or "ocean" (sovereign blue bond, blue loan, etc.) regardless of external verification. This is the broadest tier and provides headline reach.
2. ¶3 **Verified blue finance** — a subset of (1) for which a second-party opinion provider or a recognised certification scheme has confirmed alignment with a published standard (e.g., the IFC/ICMA Bonds to Finance the Sustainable Blue Economy guidance, the Climate Bonds Initiative Water Infrastructure or Marine Renewable Energy criteria, the EU Taxonomy criteria for sustainable use and protection of water and marine resources).
3. ¶4 **Criteria-documented blue finance** — where no applicable taxonomy or verification exists in the issuer's jurisdiction, the compiler should document the specific criteria applied (use of proceeds, activity list, exclusion list) and report under this tier.

¶5 A standard metadata template should accompany each published blue finance figure, recording instrument type, issuer name and sector, jurisdiction, taxonomy or criteria applied, verification status, use-of-proceeds versus performance-linked treatment, reporting period, and whether the figure is a stock or a flow. This follows the metadata transparency expectation in SNA 2025 paragraph 35.125 [15].

¶6 At the time of drafting, no universally agreed "blue finance" taxonomy exists at the international level, although several regional standards provide partial coverage. The EU Taxonomy for sustainable activities includes technical screening criteria for activities contributing to the sustainable use and protection of water and marine resources, and several other jurisdictions are developing similar standards. Compilers should document which definitions and taxonomies are applied in their compilations and monitor developments in international standard-setting for blue finance classification to support future comparability [16].

Measurement challenges

Challenge	Description
Definitional ambiguity	Unlike green finance more broadly, "blue finance" lacks universally agreed taxonomies or certification standards; compilers must document which definitions are applied (see protocol above).
Self-labelling versus verification	Instruments may be self-labelled as "blue" by issuers, verified by second-party opinion providers, or certified against standards; the SNA notes that "a combination of approaches, potentially country specific, will need to be adopted" and that "to combat concerns about 'greenwashing', it is important to provide metadata indicating the levels of assurance provided" [15] .
Attribution of multi-purpose instruments	Green bonds with mixed use of proceeds (some marine, some terrestrial) require allocation methodologies.
Stock versus flow measurement	Both the outstanding stock of blue instruments and the transactions (issuance) during a period are of analytical interest. Tables 3 and 4 below present stock and flow measures in clearly demarcated panels following IMF balance-sheet conventions.

DRAFT

Challenge	Description
International dimensions	Blue bonds may be issued in international markets and held by non-resident investors; the Balance of Payments and International Investment Position Manual (BPM7) provides guidance on recording these flows [17] .

Linking finance to outcomes

¶1 Measurement of sustainable ocean finance is most useful when linked to environmental outcomes. The SNA 2025 notes that "to support assessments of the effectiveness of sustainable finance, it is relevant to present data on the levels of investment in ESG and green activities … alongside data about the outcomes arising from that activity" [18] . For marine contexts, this means presenting blue finance data alongside:

- ¶2 Changes in ecosystem extent (hectares of marine protected areas, mangrove coverage)
- ¶3 Changes in ecosystem condition (coral reef health indices, water quality indicators)
- ¶4 Changes in ecosystem service flows (sustainable fish catch, coastal protection services)

¶5 This integration is addressed in **TG-3.1 Assets** and **TG-3.2 Flows from the Environment to the Economy**. Detailed guidance on structuring project-level blue finance instruments, including blue bonds, debt-for-nature swaps, and results-based finance, is provided in **TG-1.8 OA and Project-Level Finance**. This Circular focuses on the indicator derivation and statistical measurement aspects. Compilers should consult TG-1.8 for instrument-specific design and structuring guidance.

TG-2.6 to TNFD / IFRS / GRI indicator crosswalk

¶1 Ocean Accounts compiled under TG-2.6 provide a macro-level baseline against which entity-level sustainability disclosures by financial institutions and corporates can be contextualised. The crosswalk below maps TG-2.6 headline indicators to the corresponding entity-level metrics in TNFD, IFRS S2, and GRI 304 (with GRI 101: Biodiversity 2024 noted as the successor standard where adoption proceeds).

TG-2.6 indicator	TNFD metric	IFRS S2 / IFRS S-series	GRI disclosure
Blue bond issuance (flow)	A16.0 – Value of nature-related green finance instruments used [19]	IFRS S2 paras on transition plan financing (where ocean-linked)	GRI 304-2 / GRI 101 (location-based disclosures)
Blue bond outstanding stock	A16.0 (stock dimension)	IFRS S-series ESG financial instrument disclosures	GRI 304-2 / GRI 101
Ocean GFCF in environmental technologies	C7.3 – Capital expenditure, financing or investment deployed towards nature-related opportunities [20]	IFRS S2 (capex aligned with transition opportunities)	GRI 304-3 / GRI 101 (habitats protected or restored)
Government expenditure on marine environmental protection	C7.3 (public-sector application)	n/a	GRI 304-3 / GRI 101
Blue finance per km² of EEZ	Contextual macro metric for A16.0 disclosures	n/a	GRI 101 (location-based context)

¶2 Entity-level reporters use TG-2.6 indicators to (i) contextualise their own ocean-related disclosures against the national baseline, (ii) report consistent jurisdictional coverage of ocean activities, and (iii) demonstrate consistency between firm-level and national investment trends. For the institutional and instrument-level dimensions of this linkage, see **TG-1.7 OA and Multilateral Development Finance** and **TG-1.8 OA and Project-Level Finance**.

DRAFT

Indicator examples

¶3 From sustainable ocean finance data, the following indicators can be derived. Use-of-proceeds and performance-linked instruments are reported in separate rows to preserve their distinct analytical meaning.

Indicator	Description	Unit
Blue bond outstanding stock (use of proceeds)	Total value of use-of-proceeds blue bonds outstanding at end of period	Currency units
Blue bond issuance (use of proceeds, flow)	Value of new use-of-proceeds blue bonds issued during period	Currency units
Blue loans outstanding	Stock of loans meeting blue finance criteria	Currency units
Blue finance as share of total sustainable finance	Ocean-focused sustainable finance relative to all ESG/green finance	Percentage
Blue finance per km² of EEZ	Investment intensity relative to marine territory	Currency units per km²
Blue finance by issuer type	Disaggregated by sovereign, corporate, MDB issuers	Currency units
Memorandum: SLBs with ocean-related KPIs (extended scope)	Value of SLBs with ocean-related performance targets (general use of proceeds)	Currency units

3.5 Investment Tracking Methodology

¶1 Effective tracking of ocean investment requires integration of multiple data sources, consistent application of classification criteria, and documentation of methods to ensure comparability over time and across countries.

Tiered compilation pathway

¶1 The full seven-step procedure below assumes balanced supply-use tables, capital expenditure surveys, EPEA returns, and securities-market data, infrastructure that many small island developing States (SIDS) and least developed countries (LDCs) do not yet maintain. This Circular therefore sets out a three-tier pathway. Compilers should declare which tier their compilation reaches, and progress through the tiers as national statistical infrastructure develops.

¶2 These data-maturity tiers (Foundational, Developing, Advanced) describe *what a compiler can produce given available data*. They are distinct from, and orthogonal to, the normative scope tiers in Section 3.1 (Basic, Intermediate, Extended), which describe *what to measure*. The labels deliberately differ to prevent the two axes being conflated: a country at an early data-maturity stage may still target extended scope. Figure 2.6.1 depicts this data-maturity compilation pathway and the capabilities added at each tier.

DRAFT

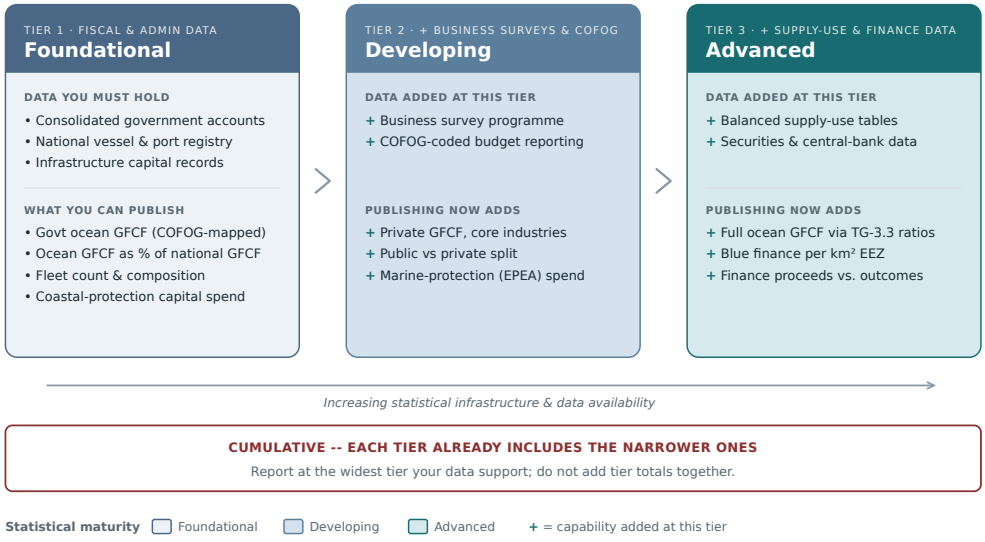


Figure 2.6.1 Ocean-investment compilation advances by cumulative data-maturity tiers from fiscal sources to supply-use GFCF tracking. Plus marks added capability; tiers are cumulative -- do not sum tier totals. Orthogonal to normative scope tiers.

Source: TG-2.6 §3.5 (tiered compilation pathway).

Adapted from: SNA 2025 §10.6--10.30 (Gross Fixed Capital Formation); SEEA CF Chapter 4 (EPEA); SF-MST §3.91 (COFOG GFCF).

DRAFT

- ¶3 **Foundational tier (fiscal accounts and administrative data).** Achievable in any country with consolidated government accounts and a national vessel registry. Outputs: government GFCF in ocean industries from budget execution data and COFOG-mapped expenditure lines, vessel-count and fleet-composition indicators from the registry, and coastal protection capital spending from infrastructure ministry records. This tier delivers a publishable headline indicator set without business surveys or SUTs.
- ¶4 **Developing tier (business surveys and COFOG-mapped expenditure).** Adds private-sector GFCF for core ocean industries (fishing/aquaculture, water transport, offshore energy) from existing business surveys or business-register-linked tax data, and a COFOG-aligned breakdown of government environmental protection expenditure. Requires a functioning business survey programme and COFOG-coded budget reporting.
- ¶5 **Advanced tier (full SUT-derived GFCF plus sustainable finance tracking).** Implements all seven steps below, including application of TG-3.3 ocean ratios to partially ocean-related industries and compilation of blue finance indicators from securities-regulator and central-bank data.

¶6 The seven-step procedure that follows is written for the Advanced tier. Foundational and Developing compilers apply only the steps relevant to their available data sources, and document the limitation explicitly in methodological notes.

Compilation procedure

¶1 **Step 1: Identify ocean industries.** Identify relevant ocean industries following the procedure in **TG-3.3** Section 3.4, to which **TG-2.5** defers its Steps 1–5.

¶2 **Step 2: Extract GFCF data from national accounts.** From the balanced national supply and use tables, extract the GFCF column for each identified ocean industry. If national SUTs aggregate in-

dustries above the ISIC class level, use supplementary business surveys or administrative records to disaggregate the relevant investment data. The GFCF column in the Use Table (see **TG-3.3** Section 3.4, Table 1) provides investment by product category, and the GFCF row by industry provides investment by producing industry.

¶3 **Step 3: Apply ocean economy ratios — documented fallback method.** For partially ocean-related industries where direct GFCF data are unavailable, multiply the GFCF by the ocean economy ratio estimated in TG-3.3. For example, if 40 per cent of coastal accommodation output serves marine tourism, apply a 0.40 ratio to the GFCF in accommodation.

> *Methodological caveat. The ocean ratios in TG-3.3 are typically derived from output or GVA data. Applying them to GFCF assumes that the ocean sub-segment of a partial industry has the same capital intensity as the non-ocean sub-segment of the same ISIC class. This proportionality assumption is known to fail where the ocean sub-segment is structurally more or less capital-intensive than its non-ocean counterpart. For example, ocean-facing coastal accommodation tends to have higher per-unit capital than inland accommodation in the same ISIC class, and fish processing plants serving marine catch may differ in equipment intensity from those serving freshwater species.*

¶4 For this reason:

- ¶5 **Preferred method.** Where capital expenditure surveys, port and vessel registry investment records, or industry-specific GFCF data exist, use these to identify ocean-related GFCF directly. The GVA-ratio approach should be reserved as a fallback.
- ¶6 **Plausibility check.** Where the ratio approach is used, compare the derived ocean GFCF share against known sub-industry characteristics (e.g., capital-output ratios for the same activity in countries with direct measurement, or against alternative sources such as port authority capital programmes) and document any material divergence.
- ¶7 **Quality flag.** Compilers should flag the use of the GVA-derived ratio assumption as a known quality limitation in the methodological notes, consistent with the quality assessment dimensions in this section.

DRAFT

¶8 **Step 4: Disaggregate investment by asset type.** Using business survey data or administrative records (vessel registries, port authority investment plans), disaggregate ocean economy GFCF into asset categories: dwellings and buildings, other structures, transport equipment (vessels), machinery and equipment, and intellectual property products. This disaggregation follows the SNA asset classification (SNA 2025 Chapter 11) and enables analysis of the composition of ocean investment.

¶9 *Vessel valuation — methods for converting registry data to monetary GFCF.* Vessel registries typically record physical characteristics (gross tonnage, deadweight, build year, vessel type) rather than monetary value. To convert physical fleet additions into GFCF-compatible monetary values, compilers can apply one or more of the following methods, in approximate order of consistency with SNA GFCF measurement:

1. ¶10 **Administrative declared value at registration.** Where the maritime authority requires declaration of acquisition value at registration, this is the simplest source. Quality depends on declaration compliance.
2. ¶11 **New-build price indices** (e.g., Clarkson Research *Shipping Review and Outlook*, or equivalent broker indices). Apply ship-type-specific new-build prices to new-registration counts. This approach is most consistent with SNA GFCF measurement at current market prices.
3. ¶12 **Enterprise book value.** Use book values from audited financial statements of vessel-owning enterprises, where reachable through business register linkage. Book values reflect accounting

depreciation rather than economic depreciation.

4. ¶13 **Perpetual inventory method (PIM)** applied to historical investment series with assumed service lives. The method is useful for stock estimates and for filling gaps in flow data.

¶14 For integration of registry, administrative, and survey sources, see **TG-4.3 Administrative Data**.

¶15 **Step 5: Compile government ocean investment from fiscal data.** Extract government GFCF from government finance statistics, identifying ocean-related functions using COFOG classes (04.2, 04.5, 05.3, 05.4) and applying the Section 3.2 guidance for isolating the maritime component of COFOG 04.5 and avoiding GFCF/EPEA double counting. Compile government environmental protection expenditure (current and capital) for marine purposes from EPEA data sources. The methodological guidance in **TG-1.1** Section 3.3 addresses the mapping of COFOG classes to ocean functions.

¶16 **Step 6: Compile sustainable ocean finance indicators.** Identify blue bonds, blue loans, and other sustainable finance instruments from financial market data, central bank statistics, and securities regulator records. Classify instruments using the three-tier protocol in Section 3.4 (self-labelled, verified, criteria-documented), keeping use-of-proceeds instruments and SLBs with ocean KPIs in separate rows. Document the taxonomy or criteria applied (e.g., EU Taxonomy, Climate Bonds Initiative marine criteria, ICMA blue economy guidance).

¶17 **Step 7: Reconcile and validate.** Ensure that the sum of ocean economy GFCF by industry is consistent with (though not necessarily identical to) the corresponding industries' investment in the broader national accounts. Document any adjustments made for ocean-specific estimation. Validate totals against alternative data sources (e.g., vessel registry investment records, port authority financial statements).

Worked example: Synthetic ocean investment tracking

¶1 Table 3 presents a worked example showing how ocean investment indicators can be compiled and presented for a hypothetical coastal state ("Country B"). All monetary values are in millions of USD. Stocks and flows are presented in separate panels and are not directly comparable: flow measures relate to transactions during the reporting period, whilst stock measures relate to the position at end of the reporting period.

DRAFT

¶2 **Table 3: Ocean Investment Tracking — Country B (Illustrative)**

¶3 *Panel A — Flow measures (during Year T)*

Investment Category	Government — Flow [Year T]	Private — Flow [Year T]	Total Flow [Year T]	Share of national GFCF (%)
Fishing and aquaculture GFCF	8	45	53	0.3
Maritime transport GFCF	15	180	195	1.0
Offshore energy GFCF	0	320	320	1.7
Port infrastructure GFCF	85	40	125	0.7
Coastal tourism GFCF	12	95	107	0.6
Shipbuilding GFCF	0	35	35	0.2
Other ocean industries GFCF	5	20	25	0.1
Total ocean economy GFCF	**125**	**735**	**860**	**4.5**
Marine environmental protection (current + capital)	65	15	80	–
Blue bond issuance (flow)	200	0	200	–

¶4 *Panel B — Stock measures (at end of Year T)*

Sustainable finance instrument	Government – Stock [end-Year T]	Private – Stock [end-Year T]	Total Stock [end-Year T]
Blue loans outstanding	0	150	150
Blue bonds outstanding (use of proceeds)	200	0	200

¶5 The data in Table 3 reveal several structural patterns. Ocean economy GFCF (Panel A) totals USD 860 million, representing 4.5 per cent of national GFCF, with private investment (USD 735 million) substantially exceeding government investment (USD 125 million). Offshore energy dominates private ocean investment at 43 per cent of private ocean GFCF. Offshore oil, gas, or wind operations are capital-intensive. Government ocean investment is concentrated in port infrastructure (68 per cent of government ocean GFCF), consistent with the public good characteristics of maritime transport infrastructure. Marine environmental protection expenditure (USD 80 million) is additional to GFCF and reflects ongoing operational and capital costs for marine conservation. The sovereign blue bond issuance of USD 200 million exceeds total government ocean GFCF. That gap suggests blue bond proceeds are being directed towards a mix of capital investment and operational marine conservation programmes.

¶6 Compilers should reproduce the Table 3 structure with their own data, leaving the "Source" and "Notes" columns to document local data decisions.

Data sources

¶1 Ocean investment data can be derived from several sources:

¶2 **National accounts and business statistics:**

- ¶3 Annual national accounts GFCF by industry
- ¶4 Business register data on enterprise characteristics
- ¶5 Capital expenditure surveys
- ¶6 Investment intentions surveys

¶7 **Government finance statistics:**

- ¶8 Government final consumption expenditure and GFCF by COFOG function
- ¶9 Budget documentation and appropriations data
- ¶10 Environmental expenditure surveys (following EPEA methodology)

¶11 **Financial sector data:**

- ¶12 Central bank data on loans by sector
- ¶13 Securities regulator data on bond issuance
- ¶14 Stock exchange data on listed companies by sector

¶15 **Administrative and specialised sources:**

- ¶16 Ship registration data (vessel values, new registrations)
- ¶17 Maritime authority permits and licences
- ¶18 Aquaculture facility registrations
- ¶19 Port authority investment records
- ¶20 Marine protected area management budgets

¶21 For guidance on survey methods and administrative data integration, see **TG-4.2 Survey Methods** and **TG-4.3 Administrative Data**.

Classification and attribution

¶1 Compilers should:

DRAFT

1. ¶2 **Document industry classification** — specify which ISIC codes are treated as "ocean industries" and how ocean-related shares are estimated for mixed industries
2. ¶3 **Apply consistent boundaries** — maintain the same definitional boundaries for the ocean economy over time, documenting any changes

¶4 For reconciliation to national totals and capitalisation thresholds, see Step 7 above.

Quality assessment

¶1 Investment data quality should be assessed against dimensions of data quality established in statistical frameworks[21]:

- ¶2 **Relevance** — do the investment indicators address user needs for understanding ocean economy development?
- ¶3 **Accuracy** — are estimates based on well-documented source data with manageable margins of error?
- ¶4 **Timeliness** — is the data available quickly enough to inform policy decisions?
- ¶5 **Coherence** — are ocean investment estimates coherent with broader national accounts and with other Ocean Accounts components?
- ¶6 **Comparability** — can the data be compared across countries and over time?

Reporting framework

¶1 A recommended reporting structure includes:

1. ¶2 **Summary table** — headline investment indicators for the most recent period and previous periods
2. ¶3 **Investment by institutional sector** — government versus private sector investment
3. ¶4 **Investment by ocean industry** — disaggregated by fishing, aquaculture, shipping, offshore energy, etc.
4. ¶5 **Investment by asset type** — structures, vessels, equipment, intellectual property
5. ¶6 **Sustainable finance** — blue bonds, blue loans, and other purpose-classified instruments
6. ¶7 **Methodological notes** — documentation of sources, classifications, and estimation methods

DRAFT

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

5. References and Further Reading

¶1 For additional guidance on the topics covered in this Circular, see:

- ¶2 **TG-0.2 Standards Overview** — for the international statistical standards underpinning the investment measurement framework
- ¶3 **TG-1.1 Budget Processes** — for guidance on government fiscal classifications and COFOG concordances
- ¶4 **TG-1.7 OA and Multilateral Development Finance** — for guidance on using Ocean Accounts in development finance contexts
- ¶5 **TG-1.8 OA and Project-Level Finance** — for guidance on blue bonds, debt-for-nature swaps, and other sustainable finance instruments
- ¶6 **TG-3.3 Economic Activity Relevant to the Ocean** — for the ocean economy thematic and extended accounting framework underpinning investment measurement

- ¶7 **TG-6.6 Deep-Sea and ABNJ** – for guidance on accounting for activities in areas beyond national jurisdiction

FOOTNOTES

1. ¶1 System of National Accounts 2025 (SNA 2025), Chapter 11 on the capital account.
2. ¶2 SNA 2025, Chapter 27 on Economic ownership and Chapter 35 on Measuring the sustainability of well-being, including discussion of natural resources and areas beyond national jurisdiction. For the corresponding external sector treatment of vessels and flags-of-convenience, see BPM7 Chapter 4 (Institutional Units and Sectors, Economic Territory, and Residence), paragraphs 4.214-4.220.
3. ¶3 SNA 2025, paragraph 35.129.
4. ¶4 United Nations (2023). *Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction* (BBNJ Agreement). Entered into force 17 January 2026.
5. ¶5 Classification of the Functions of Government (COFOG), UN Statistics Division. See also SNA 2025 discussion of government expenditure classification. The international COFOG standard halts at 4-digit class level; any further sub-class disaggregation of maritime transport within COFOG 04.5 is a national or regional statistical extension (for example, Eurostat national compilation manuals).
6. ¶6 Statistical Framework for Measuring the Sustainability of Tourism (SF-MST), paragraph 3.91.
7. ¶7 SEEA CF, paragraphs 4.62-4.68 on expenditure for environmental protection purposes.
8. ¶8 SEEA CF, paragraphs 4.85-4.88 on the definition of total national expenditure on environmental protection and the primary-purpose classification principle (consistent with CEPA 2000).
9. ¶9 SNA 2025, Chapter 11 on the capital account, particularly sections on asset classification and GFCF by asset type. Valuation guidance for produced assets on the balance sheet is set out in SNA 2025 Chapters 14 and 18.
0. ¶10 Ranges drawn from cross-country observations in the FAOSTAT Capital Stock domain (aquaculture sub-sector) and World Bank agricultural investment appraisal reports covering aquaculture project structures, machinery, buildings, and biological-asset components.
1. ¶11 SEEA CF, paragraphs 4.72-4.73 on end-of-pipe and integrated investments.
2. ¶12 SEEA CF, paragraph 4.73.
3. ¶13 SNA 2025, paragraph 35.122, adapted for ocean focus.
4. ¶14 SNA 2025, Table 35.3 showing the reporting structure for ESG and green financial instruments as “of which” items within financial instrument categories.
5. ¶15 SNA 2025, paragraph 35.125 on approaches to determining sustainable finance classification.
6. ¶16 European Commission (2020). *EU Taxonomy Regulation* (Regulation (EU) 2020/852), Article 9 and related delegated acts on technical screening criteria for the sustainable use and protection of water and marine resources. See also International Capital Market Association (ICMA) (2023), *Sustainability-Linked Bond Principles*, and IFC/ICMA *Bonds to Finance the Sustainable Blue Economy: A Practitioner’s Guide*.
7. ¶17 SNA 2025, paragraph 35.127 noting that “BPM7 also encourages countries to compile measures of ESG and green finance, for the international investment position (IIP) (stocks) and balance of payments (BOP) (flows).”
8. ¶18 SNA 2025, paragraph 35.126.
9. ¶19 Taskforce on Nature-related Financial Disclosures (TNFD) Recommendations (2023), Table 9 Additional global metrics for nature-related risks and opportunities, metric A16.0.
0. ¶20 TNFD Recommendations (2023), Table 7, metric C7.3: “Amount of capital expenditure, financing or investment deployed towards nature-related opportunities.”
1. ¶21 UN Fundamental Principles of Official Statistics and related quality frameworks such as the European Statistics Code of Practice. IMF (2014), *Balance Sheet Approach Manual*, is the source for the convention of presenting stock and flow measures in clearly demarcated panels.

DRAFT

Pollution and Other Flows to Environment

Provides operational guidance on compiling indicators of pollution and other flows from the economy to the marine and coastal environment.

Version 0.7.2 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

OUTCOME

This Circular provides operational guidance on compiling indicators of pollution and other flows from the economy to the marine and coastal environment. These indicators support evidence-based decision-making for marine spatial planning, pollution control programmes, environmental impact assessment, and SDG 14.1 reporting. Upon completing this Circular, readers will understand how to derive pollution indicators from the residual flow accounts compiled using TG-3.4 Flows from Economy to Environment, construct composite indices for marine pollution assessment, and calculate intensity and efficiency indicators that link economic activity to environmental pressures.

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 3
3.1 Pollution Indicator Framework 3
3.2 Compilation Procedure: From PSUT to Marine Indicators 5
3.3 Marine Pollution Indicators 8
3.4 Marine Litter Indicators 11
3.5 Atmospheric Deposition Indicators 13
3.6 Intensity and Efficiency Indicators 15
3.7 Worked Example: Coastal Zone Nutrient Loading Indicator 17
4. Data Sources and Compilation 18
5. Implementation Considerations 18
Prioritisation 19
Indicator presentation and communication 20
6. Acknowledgements 20
7. References 20

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Pollution and Other Flows to Environment (2026) (GOAP Technical Guidance on Ocean Accounting, TG-2.7, v0.7.2). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-2/2-7-pollution-flows/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

¶1 **Framework Position**

¶2 TG-2.7 sits at the boundary between the residual flow accounts compiled in **TG-3.4 Flows from Economy to Environment** and the policy applications addressed in **TG-1.6 OA and Environmental Impact Assessment** and **TG-2.8 Climate Change Indicators**: the Circular converts accounting data on pollution flows into decision-relevant indicators. The indicators produced through this Circular feed directly into marine spatial planning, SDG 14.1 reporting, and environmental impact assessment processes.

1. Outcome

¶1 This Circular provides operational guidance on compiling indicators of pollution and other flows from the economy to the marine and coastal environment. These indicators support evidence-based decision-making for marine spatial planning, pollution control programmes, environmental impact assessment, and SDG 14.1 reporting [1]. Upon completing this Circular, readers will understand how to derive pollution indicators from the residual flow accounts compiled using **TG-3.4 Flows from Economy to Environment**, construct composite indices for marine pollution assessment, and calculate intensity and efficiency indicators that link economic activity to environmental pressures.

2. Requirements

¶1 This Circular requires familiarity with:

- ¶2 **TG-0.1 General Introduction to Ocean Accounts** – for the conceptual framework and key components of Ocean Accounts
- ¶3 **TG-0.2 Overview of Relevant Statistical Standards** – for the methodological foundations provided by SNA 2025, SEEA CF, and SEEA EA that underpin both the residual flow accounts and the indicator derivation methods in this Circular
- ¶4 **TG-3.4 Flows from Economy to Environment** – for the accounting framework and compilation methods for residual flows to the marine environment

DRAFT

3. Guidance Material

3.1 Pollution Indicator Framework

¶1 The SEEA Central Framework supports indicator derivation through combined presentations that juxtapose physical flows with economic data [2]. For marine pollution, this framework can be extended to address the specific characteristics of ocean-related residual flows, as in Figure 2.7.1 [3].

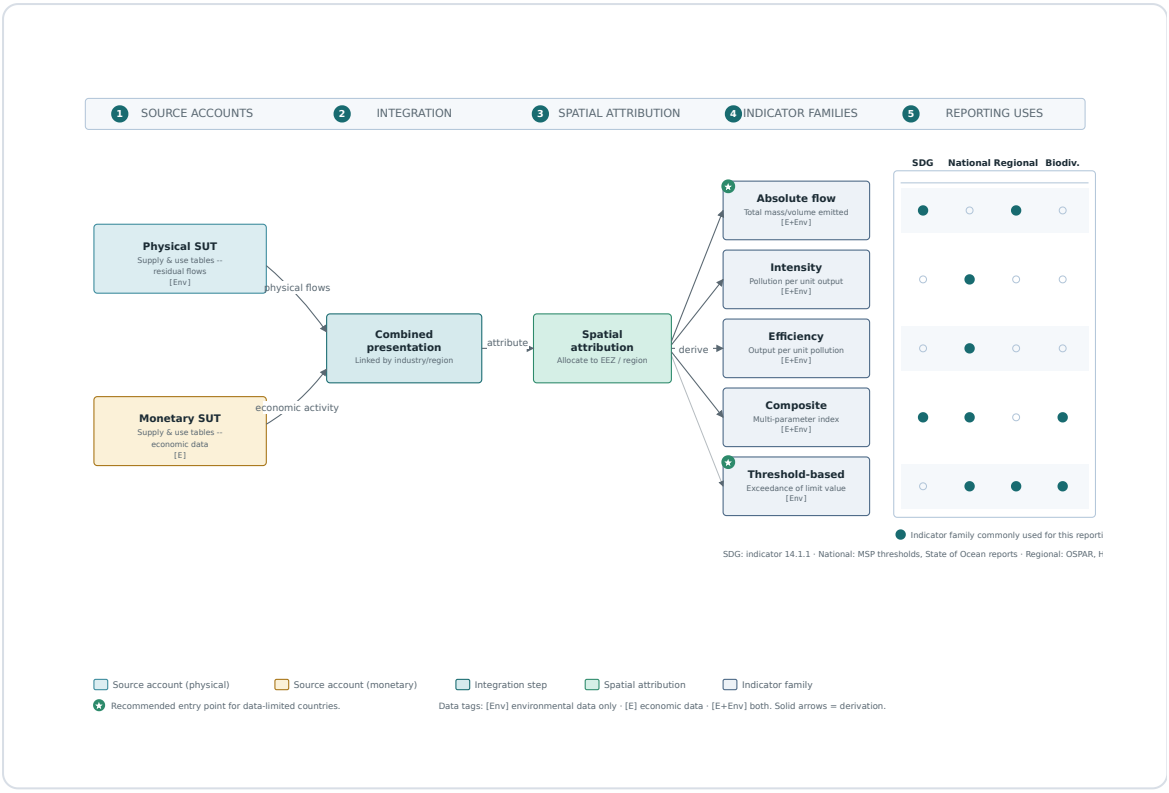


Figure 2.7.1 Physical and monetary accounts combine into five indicator families mapped to common reporting destinations. Tags: [Env], [E], [E+Env]. Stars mark recommended entry points under limited data.

Source: TG-2.7, Section 3 (accounts-to-indicators derivation) and Section 4 (indicator-family mapping).

Typology of pollution indicators

¶1 Marine pollution indicators can be classified into the categories summarised in Table 3.1.1 below.

Category	Description
Absolute flow indicators	Total quantities of pollutants discharged or emitted to the marine environment, measured in physical units (tonnes, kilograms). These indicators directly derive from the physical supply tables in residual flow accounts and provide the foundation for assessing total environmental pressure.
Intensity indicators	Ratios that relate pollution flows to measures of economic activity, such as emissions per unit of gross value added or waste generated per unit of output. Intensity indicators enable assessment of whether pollution is increasing or decreasing relative to economic scale[4] .
Efficiency indicators	Measures of how effectively economic processes convert inputs to outputs while minimising waste generation. These include material productivity (GDP per unit of material consumed) and emission efficiency (output per unit of emissions).
Composite indices	Aggregated measures that combine multiple pollution parameters into single indices for communication and monitoring purposes. SDG indicator 14.1.1 (Index of coastal eutrophication and floating plastic debris density) exemplifies this approach[5] .
Threshold-based indicators	Measures that assess pollution levels against environmental quality standards or ecological thresholds, enabling assessment of exceedance frequency and magnitude.

Linking accounts to indicators

¶1 The derivation of indicators from accounts follows the structured process summarised in Table 3.1.2 below.

Step	Description
Select relevant account entries	Identify the physical flow data from residual flow accounts corresponding to the indicator scope (e.g., nutrient emissions to coastal waters).
Determine appropriate denominators	For intensity indicators, identify the economic or production variable (output, value added, employment) to use as denominator.
Establish spatial and temporal scope	Define the geographic boundary (coastal zone, EEZ, specific water bodies) and reference period.
Apply aggregation or weighting	For composite indices, determine the aggregation method and any weights reflecting relative importance or impact of different pollutants.
Document metadata and methods	Ensure indicator derivation is transparent and reproducible, supporting quality assessment per **TG-0.7 Quality Assurance**.

¶2 The FDES 2013 Basic Set of Environment Statistics identifies specific statistics related to emissions and waste that can inform indicator development, organised under Component 3: Residuals [6]. These include emissions of greenhouse gases by sector, generation and pollutant content of wastewater, discharge of wastewater to the environment, and generation and management of waste. The FDES 2013 Core Set of Environment Statistics provides a prioritised subset of the Basic Set, and compilers should note which indicators in this Circular align with Core Set statistics, as the Core Set carries the priority for international comparability [7].

¶3 **Scope boundary – physical disturbance flows:** Physical disturbance flows (underwater noise, dredging, sediment disturbance, habitat modification) are outside the scope of this Circular. Indicator and compilation guidance for these flows is addressed in **TG-2.1 Aggregate Biophysical Indicators** and **TG-3.4 Flows from Economy to Environment**, Section 3.3.

3.2 Compilation Procedure: From PSUT to Marine Indicators

Step 1: Identify pollutant categories in residual flow accounts

¶1 The SEEA CF physical supply-use table for residuals records flows by substance or material type. For marine pollution indicators, compilers should extract the following categories from the PSUT:

¶2 **Water emissions:**

- ¶3 Nutrients: nitrogen compounds (nitrates, ammonia), phosphorus compounds
- ¶4 Organic pollutants: biological oxygen demand (BOD), chemical oxygen demand (COD)
- ¶5 Heavy metals: mercury, cadmium, lead, copper, zinc
- ¶6 Persistent organic pollutants (POPs): as listed under Stockholm Convention
- ¶7 Hydrocarbons: oil and petroleum products

¶8 **Air emissions with marine deposition:**

- ¶9 Nitrogen oxides (NOx) and ammonia (NH3) – contributing to marine eutrophication via atmospheric deposition
- ¶10 Sulphur oxides (SOx) – affecting ocean chemistry
- ¶11 Carbon dioxide (CO2) – driving ocean acidification
- ¶12 Mercury – depositing to marine waters and bioaccumulating in food webs

¶13 **Solid waste to marine environment:**

- ¶14 Plastics: by polymer type where data allow (PE, PP, PS, PET, PVC)
- ¶15 Marine litter: fishing gear (ALDFG), vessel waste, coastal litter
- ¶16 Microplastics: primary (industrial pellets, microbeads) and secondary (fragmented waste)

DRAFT

¶17 The SEEA CF Table 3.18 provides the general structure for recording solid waste flows by source and destination [8]. For marine litter accounting, the "waste to environment" category is disaggregated to distinguish waste reaching marine waters from other environmental destinations.

Step 2: Extract flows from PSUT by industry source

¶1 The physical supply table records residual generation by economic unit (industries classified by ISIC and households). For each pollutant category, compilers extract:

- ¶2 Total generation by industry (tonnes per year)
- ¶3 Industry classification (ISIC Rev.4 or national adaptation)
- ¶4 Distinction between point sources (identifiable discharge locations) and diffuse sources (distributed over area)

¶5 **Example extraction for nutrient emissions:**

ISIC	Industry	N discharge (tonnes)	P discharge (tonnes)	Source type
0111	Cultivation of cereals	15,240	2,850	Diffuse
0321	Marine aquaculture	1,850	420	Point & diffuse
1020	Fish processing	650	180	Point
3600	Water collection & treatment	8,200	1,100	Point
HH	Households	6,500	950	Point & diffuse

¶6 **Household residuals — boundary with municipal treatment systems:** Household generation should be recorded gross (before treatment) under the HH row as the total nutrient load generated at the household level. Treated discharge should be attributed to the wastewater treatment plant operator (ISIC 3600) to avoid double-counting household flows that have already been captured in the treatment system. Where PSUTs do not disaggregate household flows from mixed municipal or residential categories, compilers should estimate household nutrient generation using population and per-capita nutrient excretion coefficients. National coefficients should be used where available. In their absence, indicative values from SEEA CF Box 3.2 provide a starting point. The resulting estimates should be flagged with the appropriate TG-0.7 quality codes to document the estimation method [9].

¶7 When extracting flows for maritime NOx indicators (used in the atmospheric deposition calculation in Step 3), compilers must exclude inland water transport (ISIC 5021–5022) from the maritime-destined atmospheric deposition sub-total. For the full scope definition of maritime NOx emissions, including the rationale for this exclusion, see the Maritime NOx indicator specification in Section 3.5.

¶8 The SEEA CF methodology for recording solid waste flows by source and destination is described in SEEA CF paras 3.268-3.277. For the general principles of attributing residual flows to source industries within the physical supply-use framework, see SEEA CF paras 3.99-3.109. Attribution should record flows to the industry that generates the residual rather than the industry that manages or treats it, and this attribution should be applied consistently across pollutant categories (unless treatment is incomplete and residuals are released).

Step 3: Apply spatial attribution to identify marine-destined flows

¶1 Not all residuals recorded in the PSUT reach the marine environment. Spatial attribution requires:

DRAFT

¶2 **Hydrological connectivity analysis** — identify catchments that drain to coastal waters, and estimate nutrient transport coefficients accounting for in-stream retention:

```
Marine load = Catchment generation × Delivery ratio
```

¶3 Delivery ratios typically range from 0.05 to 0.40 depending on distance to coast, soil type, vegetation cover, and retention in waterways. Higher delivery ratios apply to short, steep catchments with limited riparian buffers. Lower ratios apply to flat, heavily vegetated catchments where significant in-stream retention occurs. Compilers should select the delivery ratio method from the following four-level tiered protocol, applied in order of preference:

1. ¶4
   Tier 1 — Modelled national or OECD ratios: Use ratios derived from national hydrological models or OECD Gross Nitrogen Balance guidance where these are available and applicable to the catchment hydrology. The OECD Gross Nitrogen Balance methodology provides guidance on estimating nutrient delivery from agricultural catchments to receiving waters[10]. This tier applies primarily to temperate agricultural systems in OECD member states.
2. ¶5
   Tier 2 — Regional sea or river-basin studies: Where OECD or national modelled ratios are unavailable or not applicable (e.g., small island states, tropical coastlines, monsoon-dominated basins), use delivery ratios from regional sea assessments or peer-reviewed river-basin studies covering comparable hydrological and geomorphological conditions.
3. ¶6
   Tier 3 — Simplified export-coefficient approaches: Where neither Tier 1 nor Tier 2 sources are available, apply simplified export-coefficient methods — for example, USGS SPARROW model coefficients adapted for tropical catchments, or FAO Land and Water Division guidance on nutrient export coefficients for tropical agriculture[11]. These methods are less precise but documented and reproducible.
4. ¶7
   Tier 4 — Low-confidence documented fallback: Where no validated source is available, assume a delivery ratio consistent with the general range (0.05–0.40), document the assumed value and its justification, and flag the resulting indicator as low-confidence using the appropriate TG-0.7 quality codes. Do not use undocumented or arbitrary coefficients.

¶8 **Direct discharge identification** — for point sources (wastewater treatment plants, industrial outfalls), use administrative records to identify facilities discharging to coastal waters versus inland waters.

¶9 **Atmospheric transport modelling** — for air emissions, use atmospheric deposition models (e.g., EMEP, GEOS-Chem) to estimate the fraction depositing to marine waters within the EEZ. Where atmospheric models are unavailable, compilers may use deposition budget outputs published by regional sea conventions — for example, HELCOM Pollution Load Compilation or OSPAR deposition budget assessments — as documented simplified sources applicable to their regional context[12]. If no validated method is available for the compiler's region, atmospheric deposition should be reported as "not compiled" rather than estimated with undocumented coefficients. Omitting this component is preferable to introducing unverifiable estimates, and the absence should be noted in the indicator metadata.

¶10 **Marine litter leakage rates** — estimate the fraction of mismanaged waste reaching marine waters using methodologies such as Jambeck et al. (2015)[13], which incorporates coastal population, waste management infrastructure, and proximity to shore.

Step 4: Compute indicator values

¶1 With marine-attributed flows identified, compute indicator values:

DRAFT

¶2 **Absolute indicators:**

```
Total marine nutrient loading = Sum of N flows to marine waters (tonnes N/yr)
```

¶3 **Intensity indicators:**

```
Nutrient intensity = Marine nutrient loading / Ocean economy GVA (kg N per
million currency)
```

¶4 The ocean economy GVA denominator is compiled as described in **TG-3.3 Economic Activity Relevant to the Ocean**, ensuring consistency between the numerator (pollution) and denominator (economic activity driving pollution).

¶5 **Spatial indicators:**

```
Nutrient loading density = Marine nutrient loading / Coastal zone area (kg N
per km²)
```

¶6 **Temporal indicators:**

```
Loading change rate = (Current year loading - Base year loading) / Base
year loading
```

Step 5: Quality assessment and uncertainty quantification

¶1 Pollution indicators inherit uncertainty from multiple sources: measurement error in residual flow accounts, uncertainty in spatial attribution (delivery ratios, atmospheric deposition fractions), and sampling variability in monitoring data. Indicators compiled via spatial attribution carry multiplicative uncertainty that compounds across the delivery ratio, deposition fraction, and leakage rate assumptions. Compilers should:

- ¶2 Document methods and assumptions for each step
- ¶3 For each key spatial attribution assumption (delivery ratio, atmospheric deposition fraction, marine leakage rate), document the uncertainty range or plausible bounds
- ¶4 Compute the indicator under low and high assumption scenarios to derive an uncertainty range
- ¶5 Present the central estimate alongside its uncertainty range, and do not publish a single-point estimate without indicating the plausible range
- ¶6 Apply a standard multiplicative uncertainty propagation formula — for example, the approach described in JCGM 100:2008 (GUM) for combined uncertainty in indirect measurements [14]
- ¶7 Validate indicator trends against independent monitoring data (e.g., compare estimated nutrient loads with measured concentrations in coastal waters)
- ¶8 Apply quality flags following **TG-0.7 Quality Assurance**

¶9 The SEEA CF principle of recording flows at the point of generation (rather than point of ultimate environmental impact) means that accounts-based indicators measure pressure rather than state. Compilers should clearly communicate that nutrient loading indicators, for example, represent inputs to marine waters, not resulting water quality. The link between loading (pressure) and concentration (state) depends on hydrodynamic dilution, biological uptake, and other factors addressed in ecosystem condition accounts.

3.3 Marine Pollution Indicators

Nutrient pollution indicators

DRAFT

¶1 Nutrient pollution (nitrogen and phosphorus compounds) contributes to coastal eutrophication and is addressed by SDG Target 14.1, with indicator 14.1.1 including a coastal eutrophication index[15], [16].

¶2 **Recommended nutrient indicators:**

Indicator	Definition	Unit	Source Data	Compilation Note
Total nitrogen discharge to coastal waters	Sum of nitrogen compounds discharged to coastal and marine waters from point and non-point sources	tonnes N/year	Water emissions account	Apply delivery ratios to catchment sources
Total phosphorus discharge to coastal waters	Sum of phosphorus compounds discharged to coastal and marine waters from point and non-point sources	tonnes P/year	Water emissions account	Apply delivery ratios to catchment sources
Agricultural nutrient surplus to coastal zones	Excess of nutrient inputs over crop uptake in coastal catchments	kg N/ha, kg P/ha	Agricultural statistics, land cover data	Use OECD Gross Nutrient Balance method
Nutrient loading intensity	Nutrient discharge per unit coastal zone area	kg N/km², kg P/km²	Water emissions account, spatial data	Compare to ecological thresholds
Wastewater nutrient discharge	Nutrient load in treated and untreated wastewater discharged to marine waters	tonnes N/year, tonnes P/year	Wastewater discharge records	Distinguish by treatment level

¶3 The OECD/Eurostat Gross Nitrogen Balances and Gross Phosphorus Balances methodologies provide standardised approaches for calculating agricultural nutrient balances that can be applied to coastal catchments[10]. The SEEA Agriculture, Forestry and Fisheries (SEEA AFF) guidance extends these methodologies within an accounting framework[17].

¶4 Compilation of nutrient indicators should:

- ¶5 Distinguish between point sources (industrial and municipal discharges with identifiable locations) and diffuse sources (agricultural runoff, urban stormwater)
- ¶6 Apply appropriate models or coefficients to estimate nutrient transport from catchments to coastal waters, accounting for in-stream retention and transformation
- ¶7 Attribute emissions to industries using ISIC classification, enabling analysis of sectoral contributions

¶8 The relationship between nutrient loading indicators (pressure) and marine ecosystem condition indicators such as dissolved oxygen levels, chlorophyll-a concentrations, and habitat quality scores is addressed in **TG-2.1 Aggregate Biophysical Indicators**. Understanding this pressure-state linkage is central to interpreting nutrient indicators in a policy context.

Chemical pollution indicators

¶1 **Recommended chemical pollution indicators**, following the FDES basic set for releases of chemical substances[18]:

DRAFT

Indicator	Definition	Unit	Source Data	Compilation Note
Heavy metal discharges	Discharge of specified heavy metals (Hg, Cd, Pb, Cu, Zn) to coastal and marine waters	kg/year by metal	Pollution inventories, industrial discharge records	Priority: Hg, Cd, Pb per Stockholm/Minamata Conventions. Each substance must be recorded individually; do not aggregate with equivalence weights unless specifically required for a reporting framework. Monitoring registry data (e.g., E-PRTR equivalents) may substitute for PSUT-sourced values where PSUT disaggregation to substance level is not available; document the substitution and flag with TG-0.7 quality codes. For unmeasured substances, report as "not compiled" rather than zero. See SEEA CF Table 3.18 for the row/column structure required for substance-level disaggregation[8] .
POPs discharges	Discharge of persistent organic pollutants to marine waters	kg/year by substance	Chemical release inventories	Stockholm Convention substances. Record each substance individually per SEEA CF Table 3.18. Monitoring registry data may substitute for PSUT-sourced values; document substitution and apply TG-0.7 quality flags.
Antifouling compound release	Estimated release of antifouling biocides from vessel hulls	kg/year	Vessel registry, coating data	Tributyltin (TBT) and copper-based

¶2 For indicators of oil and petroleum product discharges to marine waters, see the Hydrocarbon pollution indicators sub-section below.

¶3 The measurement of chemical pollutants presents challenges due to the large number of substances, varying analytical methods, and difficulty in estimating diffuse sources. The European Pollutant Release and Transfer Register (E-PRTR) and similar national registries provide models for point source reporting[19]. For ocean accounting, priority should be given to chemicals:

- ¶4 Subject to international regulation (Stockholm Convention POPs, Minamata Convention mercury)
- ¶5 Of particular concern for marine ecosystems (tributyltin, microplastics)
- ¶6 With established monitoring and reporting systems

¶7 **Data-scarce context — countries without a Pollutant Release and Transfer Register (PRTR):** Many national statistical offices, particularly in developing countries and small island states, have no PRTR or equivalent national registry. In these contexts, a minimum compilation approach comprises: (1) use UNEP GEMS/Water global water quality monitoring data as a proxy for point-source chemical concentrations where available; (2) estimate emissions using sectoral activity data (mining output volumes, industrial production indices) combined with substance-specific emission factors from IPCC/EMEP emission factor compilations; (3) flag all estimates compiled without PRTR data using the appropriate TG-0.7 quality codes to communicate data source limitations. The UNEP Guidance on Developing National Pollutant Release and Transfer Registers (2006)[20] sets out a capacity-building pathway toward establishing national systems. Even partial indicators compiled under this approach contribute to international comparability and SDG reporting coverage, and data scarcity alone is not grounds for omitting them.

Hydrocarbon pollution indicators

¶1 **Recommended hydrocarbon indicators:**

DRAFT

Indicator	Definition	Unit	Source Data	Compilation Note
Operational oil discharge from vessels	Oil discharged through normal vessel operations	tonnes/year	Port reception facility records (IMO GISIS database [21]); vessel surveys for compliant at-sea discharges	**MARPOL Annex I scope:** Machinery space (bilge water) discharges are governed by MARPOL Annex I Regulation 15 (effluent must not exceed 15 ppm; vessels ≥400 GT must have approved oily water separators). Cargo tank washing discharges from oil tankers are governed by MARPOL Annex I Regulation 34 (effluent must not exceed 15 ppm; discharge only outside special areas and >50 nm from land). Port reception facility records capture discharges that are offloaded; legally compliant at-sea discharges (≤15 ppm) are not required to be offloaded and represent a systematic data gap that should be acknowledged in the indicator metadata.
Accidental oil spills	Volume of oil released through accidental spills	tonnes/year; number of spills	Maritime incident records (EMSA datasets, IMO GISIS)	Distinguish by spill size class. MARPOL Annex I reporting.
Offshore operational discharge	Oil in produced water and other discharges from offshore installations	tonnes/year	Operator reporting	Link to offshore energy accounts
Land-based hydrocarbon runoff	Oil entering marine waters from urban and industrial runoff	tonnes/year	Estimated from land use and runoff models	High uncertainty; validate with monitoring

DRAFT

¶2 The ratio of accidental spills to total oil transport provides an indicator of maritime safety performance, whilst the trend in operational discharges indicates progress in compliance with MARPOL regulations [22].

¶3 For offshore petroleum activities, additional guidance on accounting for operational discharges is provided in **TG-3.10 Offshore Energy**. The broader context of marine litter (including oil-contaminated debris) is addressed in **TG-6.12 Marine Litter and Plastics Accounting**.

3.4 Marine Litter Indicators

¶1 SDG Target 14.1 addresses marine debris, with indicator 14.1.1 including floating plastic debris density [23]. The Intergovernmental Negotiating Committee (INC) process under UNEA Resolution 5/14 has been working toward a global plastics treaty [24]. Compilers should monitor the outcomes of INC sessions for potential new mandatory reporting requirements on plastic waste that may affect indicator specifications in future revisions of this Circular.

Plastic pollution indicators

¶1 **Recommended plastic pollution indicators:**

Indicator	Definition	Unit	Source Data	Compilation Note
Plastic waste generation	Total plastic waste generated by all sources	tonnes/year	Waste statistics	Disaggregate by polymer type where possible
Mismanaged plastic waste	Plastic waste not properly disposed or recycled	tonnes/year	Waste management statistics	Share of total generation
Plastic leakage to ocean	Estimated plastic waste entering marine environment	tonnes/year	Modelling (Jambeck methodology) [13]	Apply coastal leakage coefficients; see uncertainty note below
Coastal plastic waste intensity	Plastic waste generated per km of coastline	tonnes/km/year	Waste statistics, coastal length	Identify hot-spots
Beach litter density	Count or mass of litter per beach survey area	items/m², kg/m²	Beach survey programmes	OSPAR/HELCOM protocols
Floating debris density	Density of floating debris in surface waters	items/km²	At-sea visual surveys	SDG 14.1.1 component
Microplastic concentration	Concentration of microplastic particles in marine waters	particles/m³	Water sampling	Document size detection limits; state monitoring variable only – see microplastics boundary note below

¶2 The Taskforce on Nature-related Financial Disclosures (TNFD) framework identifies plastic footprint as a specific disclosure metric, defined as total weight of plastics used or sold, disaggregated by reusable, compostable, and technically recyclable categories [25].

¶3 For practical compilation, the approach developed by Jambeck et al. (2015) provides a methodology for estimating plastic leakage from waste generation, mismanagement rates, and proximity to coastlines [13]. This methodology can be adapted to national contexts using locally-sourced waste statistics. **Uncertainty in Jambeck-derived estimates:** The Jambeck methodology carries substantial uncertainty – published estimates span approximately one order of magnitude across scenarios, reflecting uncertainty in waste generation rates, mismanagement rates, and coastal proximity assumptions. Compilers must accompany any plastic leakage indicator derived from this methodology with a stated confidence range reflecting the low and high scenarios. Presenting a single central estimate without bounds is not appropriate for official statistics. Assign TG-0.7 quality flags for modelled estimates to communicate the estimation basis. Where beach survey data, at-sea debris observations, or national waste audit data are available, these should be used to validate or constrain the modelled estimate. More recent global waste model updates (Borrelle et al. 2020 [26]; Lau et al. 2020 [27]) may provide updated coefficient ranges for sensitivity testing.

¶4 **Microplastics boundary – accounting classification:** The boundary between microplastics as a water emission and as a solid waste entry requires explicit treatment to prevent double-counting across TG-2.7 and **TG-3.4 Flows from Economy to Environment**. This Circular adopts the following classification. **Primary microplastics** (industrial pellets, microbeads, and other microplastic particles released directly to water from industrial or consumer processes) are classified as water emissions and recorded as a flow entry in the residual flow accounts. **Secondary microplastics** (particles that fragment from macroplastic solid waste already present in the marine environment) represent stock changes within the marine litter account rather than new economy-to-environment

DRAFT

flows, and should not be recorded as a new emission flow. **Water column microplastic concentration** is an environmental monitoring variable, a state indicator rather than an accounting flow, and should not be entered as a residual flow in the PSUT. Compilers implementing both TG-2.7 and TG-3.4 should apply this classification consistently. For the full treatment of marine litter stock-flow accounts, including the marine litter asset account within which secondary microplastic stock changes are recorded, see **TG-6.12 Marine Litter and Plastics Accounting**. [28]

Other marine debris indicators

¶1 Beyond plastics, marine litter includes fishing gear, packaging, and other materials.

¶2 **Recommended debris indicators:**

Indicator	Definition	Unit	Source Data	Compilation Note
Abandoned, lost or discarded fishing gear (ALDFG)	Quantity of fishing gear entering marine environment	tonnes/year; items/year	Fisheries surveys, gear loss reporting	See ALDFG compilation note below
Derelict vessel count	Number of abandoned vessels in coastal waters	count	Maritime registries, surveys	
Litter composition	Proportion of litter by material category	percentage	Beach and seabed surveys	
Litter removal	Quantity of litter removed from marine environment	tonnes/year	Clean-up programme records	

¶3 **ALDFG compilation method:** Abandoned, lost or discarded fishing gear (ALDFG) is rarely collected systematically in national fisheries statistics. Compilers should apply the following tiered approach: (1) as the primary data source, use gear loss rate surveys conducted following the FAO Voluntary Guidelines on the Marking of Fishing Gear (2019) [29] and associated FAO Technical Guidelines for Responsible Fisheries on ALDFG; (2) as a secondary method where surveys are unavailable, apply gear-specific loss rate coefficients to fleet activity data (vessel-days by gear type) — loss rate coefficients by gear type are available from the Global Ghost Gear Initiative data framework; (3) document minimum metadata requirements distinguishing survey-based from modelled estimates, including the survey coverage (percentage of fleet observed), gear types covered, and the coefficient source. Estimates derived from loss rate coefficients rather than direct surveys should be flagged with TG-0.7 quality codes indicating the modelled basis.

¶4 The SF-MST (Statistical Framework for Measuring the Sustainability of Tourism) provides guidance on tourism solid waste accounting relevant to coastal tourism waste generation [30].

3.5 Atmospheric Deposition Indicators

¶1 Key substances include nitrogen compounds (contributing to marine eutrophication), sulphur compounds (affecting ocean chemistry), carbon dioxide (driving ocean acidification), and mercury (entering marine food webs via atmospheric deposition) [31].

¶2 This pathway is addressed in **TG-3.4 Flows from Economy to Environment**, Section 3.1, which notes that "the accounting challenge is to link atmospheric emissions to their marine deposition, which requires integration with atmospheric modelling or use of deposition coefficients." This Circular addresses the indicator derivation aspect of this challenge.

Atmospheric nitrogen deposition

¶1 The SEEA Technical Note on Air Emissions Accounting provides guidance on air emissions accounts that form the basis for deposition estimates [32].

DRAFT

¶2 **Recommended atmospheric deposition indicators:**

Indicator	Definition	Unit	Source Data	Compilation Note
Atmospheric nitrogen emissions (relevant sectors)	NOx and NH3 emissions from sectors contributing to marine deposition	tonnes N/year	Air emissions account	Focus on coastal zone sources
Estimated nitrogen deposition to marine waters	Nitrogen deposited to EEZ waters from atmospheric emissions	tonnes N/year	Atmospheric deposition models	High uncertainty; document assumptions. Report as "not compiled" if no validated method is available; do not estimate with undocumented coefficients.
Maritime NOx emissions	NOx emissions from sea and coastal water transport only (ISIC 5011–5012). **Excludes inland water transport (ISIC 5021–5022):** inland shipping NOx deposits principally over rivers and estuaries rather than open marine waters and must not be included in this indicator.	tonnes NOx/year	Air emissions account, maritime data	Authoritative scope definition; compilers extracting flows in Step 2 should apply this exclusion to the maritime-destined atmospheric deposition sub-total.

¶3 The estimation of actual deposition requires atmospheric transport and deposition modelling, which may be beyond the capacity of many national statistical systems. A pragmatic approach is to report emissions from relevant sectors (agriculture, transport, energy) that contribute to deposition, whilst noting that the relationship between emissions and marine deposition depends on atmospheric conditions and distance to coast. Where deposition modelling capacity is unavailable, compilers should consult HELCOM Pollution Load Compilation or OSPAR deposition budget outputs as documented regional sources before concluding that atmospheric deposition cannot be estimated [12].

DRAFT

Ocean acidification indicators

¶1 Ocean acidification is addressed by SDG Target 14.3, with indicator 14.3.1 tracking average marine acidity measured at representative sampling stations [33]. Indicators linking economic activity to acidification drivers are relevant for ocean accounting.

¶2 **Recommended acidification-related indicators:**

Indicator	Definition	Unit	Source Data	Compilation Note
Total CO2 emissions	National total carbon dioxide emissions	tonnes CO2/year	Air emissions account	Link to UNFCCC inventory
Maritime CO2 emissions	CO2 emissions from domestic and international shipping	tonnes CO2/year	Air emissions account	ISIC 5011-5012
CO2 emission intensity	CO2 emissions per unit GDP	kg CO2/currency unit	Air emissions account, national accounts	Track decoupling
Cumulative CO2 emissions	Historical total emissions contributing to atmospheric CO2 stock	tonnes CO2	Aggregated air emissions time series	Carbon budget context

¶3 The relationship between national emissions and ocean acidification is mediated by global atmospheric mixing, meaning that national emissions contribute to global rather than specifically national marine acidification. The full treatment of climate-ocean indicators is provided in **TG-2.8 Climate Change Indicators**, which addresses ocean acidification indicators in detail in Section 3.3.

Mercury deposition indicators

¶1 Mercury enters marine food webs through atmospheric deposition and bioaccumulates in fish, posing human health risks. The Minamata Convention on Mercury establishes international reporting requirements [34].

¶2 **Recommended mercury indicators:**

Indicator	Definition	Unit	Source Data
Mercury emissions to air	Total atmospheric mercury emissions	kg Hg/year	Air emissions account
Mercury emissions by sector	Mercury emissions from major source categories	kg Hg/year by sector	Air emissions account
Artisanal gold mining mercury use	Mercury used in artisanal and small-scale gold mining	kg Hg/year	Minamata Convention reporting

3.6 Intensity and Efficiency Indicators

¶1 Intensity and efficiency indicators relate pollution flows to measures of economic activity, enabling assessment of decoupling [35], [36]. They link the economic activity data compiled under **TG-3.3 Economic Activity Relevant to the Ocean** to the residual flow data compiled under **TG-3.4 Flows from Economy to Environment**.

Pollution intensity indicators

¶1 **Recommended intensity indicators:**

Indicator	Definition	Unit	Interpretation
Nutrient discharge intensity	Nutrient discharge per unit GVA	kg N/million currency; kg P/million currency	Lower values indicate cleaner production
Waste generation intensity	Solid waste generated per unit GVA	tonnes/million currency	Declining trend indicates relative decoupling
Emission intensity by industry	Industry emissions per unit industry GVA	varies by pollutant	Enables inter-industry comparison
Coastal tourism waste intensity	Waste generated per tourist-night	kg/tourist-night	Links tourism pressure to activity level
Aquaculture emission intensity	Nutrient discharge per tonne production	kg N/tonne fish; kg P/tonne fish	Indicates aquaculture environmental efficiency

¶2 Intensity indicators should be calculated separately for key ocean-related industries as identified in **TG-3.3 Economic Activity Relevant to the Ocean**:

- ¶3 Fishing (ISIC 031)
- ¶4 Aquaculture (ISIC 032)
- ¶5 Fish processing (ISIC 1020)
- ¶6 Water transport (ISIC 50)
- ¶7 Coastal tourism (ISIC 55, 79, 93)
- ¶8 Offshore extraction (ISIC 06, 09)

Decoupling indicators

DRAFT

¶1 Decoupling indicators assess whether environmental pressure is growing slower than (relative decoupling) or declining absolutely whilst the economy grows (absolute decoupling)[37].

¶2 **Recommended decoupling indicators:**

Indicator	Definition	Formula	Interpretation
Pollution-GDP decoupling factor	Rate of change in pollution relative to GDP growth	(% change pollution) / (% change GDP)	<1 indicates relative decoupling; <0 indicates absolute decoupling. This ratio assumes positive GDP growth. **Recession-period interpretation:** in years of economic contraction, a fall in pollution may reflect reduced economic activity rather than genuine efficiency improvement, and the ratio can produce a spuriously positive decoupling signal. During periods of economic contraction, compilers should: (i) use potential GDP (a measure of trend output that removes cyclical fluctuations) as an alternative denominator, following OECD (2002) guidance on decoupling indicators for non-stable growth periods[38]; (ii) present absolute pollution levels and emission intensity trends separately alongside the ratio, rather than relying on the ratio alone; and (iii) contextualise results with a note explaining the economic cycle.
Material productivity	GDP per unit domestic material consumption	GDP / DMC	Rising trend indicates improved material efficiency
Water productivity	GVA per unit water abstraction	GVA / water use (m^3)	Rising trend indicates improved water efficiency

¶3 The interpretation of decoupling requires time series data. Single-period ratios provide intensity measures, but decoupling assessment requires comparison of percentage changes over multiple periods.

¶4 Additional guidance on resource efficiency indicators is provided in **TG-2.11 Resource Efficiency**.

DRAFT

Combined presentation for indicators

¶1 Following the SEEA Central Framework approach, a combined presentation for marine pollution indicators would include[39]:

Data Element	Physical Units	Monetary Units	Indicator Derived
Output by ocean industry	–	Currency	Denominator for intensity
Gross value added by ocean industry	–	Currency	Denominator for intensity
Employment by ocean industry	Persons	–	Employment intensity
Nutrient discharge to marine waters	tonnes N, tonnes P	–	Absolute pressure indicator
Solid waste to marine environment	tonnes	–	Marine litter indicator
CO2 emissions from ocean industries	tonnes CO2	–	Carbon intensity
Environmental protection expenditure	–	Currency	Response indicator
Environmental taxes paid	–	Currency	Policy instrument indicator

¶2 The indicator categories derived from this combined presentation follow the five-category typology defined in Section 3.1. The structure aligns with that recommended in **TG-3.4 Flows from Economy to Environment**, Section 3.4, ensuring consistency between accounting and indicator frameworks.

3.7 Worked Example: Coastal Zone Nutrient Loading Indicator

Context

¶1 Coastal Zone Alpha is a 50 km stretch of coastline with intensive aquaculture (5 farms producing 8,000 tonnes/year of finfish), one urban wastewater treatment plant serving a population of 120,000, and agricultural catchments draining 15,000 hectares of cropland to coastal waters. The zone experiences periodic algal blooms, and planners require a nutrient loading indicator to support marine spatial planning decisions.

Step 1: Extract nutrient flows from residual accounts

¶1 From the national physical supply-use table for water emissions (compiled per **TG-3.4**), extract nitrogen discharge for Zone Alpha:

Source	ISIC	N discharge (kg/yr)	Data source
Marine aquaculture	0321	184,000	Farm environmental reports
Urban wastewater	3600	96,000	WWTP discharge permits
Agricultural runoff	0111	225,000	Modelled using OECD N-balance
Total generation		**505,000**	

Step 2: Apply spatial attribution

¶1 Not all generated nitrogen reaches marine waters. Apply delivery ratios:

Source	Generation (kg N/yr)	Delivery ratio	Marine load (kg N/yr)	Justification
Aquaculture	184,000	1.00	184,000	Direct to coastal waters
WWTP	96,000	0.95	91,200	Outfall 2 km offshore; minimal in-situ processing
Agriculture	225,000	0.18	40,500	15 km average distance to coast; riparian retention
Total marine load			**315,700**	

DRAFT

¶2 The agricultural delivery ratio of 0.18 is applied as a Tier 1 estimate based on OECD guidance for mixed cropland catchments with moderate riparian buffers. A sensitivity analysis under Tier 1 uncertainty bounds gives delivery ratios ranging 0.12–0.25 depending on rainfall intensity and vegetative cover, and the resulting total marine load range is approximately 302,000–331,000 kg N/yr. This uncertainty range should be reported alongside the central estimate.

Step 3: Compute indicator values

¶1 **Absolute loading indicator:**

```
Total nitrogen load to Zone Alpha = 315,700 kg N/yr = 316 tonnes N/yr
```

¶2 **Spatial intensity indicator:**

```
Loading per coastline length = 316 tonnes / 50 km = 6.3 tonnes N per km per year
```

¶3 **Loading per unit coastal zone area:**

```
Coastal zone area = 50 km × 5 km (avg width) = 250 km²
Loading density = 316 tonnes / 250 km² = 1.26 tonnes N per km² per year
```

¶4 **Source attribution:**

- ¶5 Aquaculture: 58% of marine load
- ¶6 Wastewater: 29% of marine load
- ¶7 Agriculture: 13% of marine load (though 45% of gross generation)

Step 4: Compare to thresholds

¶1 The OSPAR eutrophication strategy suggests coastal zones with loading exceeding 1.0 tonne N/km²/yr may be at elevated eutrophication risk. Zone Alpha exceeds this threshold, indicating policy intervention may be warranted (the OSPAR value is a regional threshold: compare against the ecological threshold that applies locally, as the nutrient loading intensity row in Section 3.3 requires).

Step 5: Link to economic activity

¶1 From ocean economy accounts (**TG-3.3**), Zone Alpha aquaculture GVA is 12.5 million currency units per year:

```
Aquaculture N intensity = 184 tonnes N / 12.5 million currency = 14.7 kg N per
thousand currency GVA
```

¶2 This intensity can be compared across zones or tracked over time to assess whether nutrient loading is decoupling from aquaculture production.

Policy interpretation

¶1 The indicator compilation reveals that whilst aquaculture contributes the majority (58%) of nitrogen reaching coastal waters, agricultural sources represent 45% of gross generation but only 13% of marine load due to retention in the catchment-to-coast pathway. Policy interventions focused solely on aquaculture may achieve 58% reduction potential, whilst interventions targeting agricultural practices have lower marine impact due to natural attenuation. The indicator supports prioritisation of aquaculture best management practices (reduced feed conversion ratios, improved waste collection) and WWTP upgrades, whilst agricultural interventions may be warranted for broader environmental benefits beyond marine loading.

DRAFT

4. Data Sources and Compilation

> ¶1 ⓘ **Section schema**
> ¶2 This circular uses an extended six-section schema (Sections 1-3 standard, Section 4 Data Sources and Compilation, Section 5 Implementation Considerations, Section 6 Acknowledgements, Section 7 References). The extension accommodates the multi-source compilation procedure and tiered implementation guidance required for pollution indicators. Cross-references from other circulars to "Acknowledgements" or "References" in TG-2.7 should target Sections 6 and 7 respectively. All other circulars follow the canonical four-section schema (Sections 1-3 substantive, Section 4 Acknowledgements, Section 5 References) defined in the GOAP Circular Style Guide.

¶3 Compilation of pollution indicators draws on the residual flow accounts established under **TG-3.4 Flows from Economy to Environment**, supplemented by additional data sources for indicator derivation. **TG-4.2 Statistical Sources and Data Gaps** provides a full inventory of monitoring data sources and quality assessment procedures for pollution indicators, including national accounts denominators, spatial data, and international reporting framework alignment. [40]

5. Implementation Considerations

Prioritisation

¶1 Given resource constraints, compilers should prioritise indicators based on:

1. ¶2 **Policy relevance** — indicators that address national marine policy priorities and international commitments (particularly SDG 14)
2. ¶3 **Data availability** — indicators for which underlying data can be compiled from existing sources
3. ¶4 **Trend monitoring** — indicators that can be compiled consistently over time for trend analysis
4. ¶5 **Sectoral attribution** — indicators that enable identification of industries responsible for environmental pressure

¶6 To translate these criteria into an actionable indicator shortlist, the following three-tier implementation framework maps all indicators in this Circular to implementation capacity levels. Tier 1 is the minimum set recommended for all countries. Tier 2 is an intermediate set for countries with established environmental monitoring infrastructure, and Tier 3 is the full set for countries with full PSUT and modelling capacity. All Tier 1 indicators align with SDG 14.1.1 components or the FDES 2013 Core Set of Environment Statistics [7].

¶7 **Table 5.1: Tiered implementation framework for TG-2.7 pollution indicators**

Indicator	Category	Section	Tier	FDES Core Set
Total nitrogen discharge to coastal waters	Nutrient	3.3	1	Yes
Total phosphorus discharge to coastal waters	Nutrient	3.3	1	Yes
Wastewater nutrient discharge	Nutrient	3.3	1	Yes
Plastic waste generation	Marine Litter	3.4	1	Yes
Mismanaged plastic waste	Marine Litter	3.4	1	Yes
Floating debris density (SDG 14.1.1)	Marine Litter	3.4	1	Yes
Total CO2 emissions	Atmospheric/Acidification	3.5	1	Yes
Heavy metal discharges (Hg, Cd, Pb priority)	Chemical	3.3	2	No
POPs discharges	Chemical	3.3	2	No
Plastic leakage to ocean (Jambeck-derived)	Marine Litter	3.4	2	No
Beach litter density	Marine Litter	3.4	2	No
ALDFG	Marine Litter	3.4	2	No
Atmospheric nitrogen emissions (relevant sectors)	Atmospheric/Acidification	3.5	2	No
Maritime CO2 emissions	Atmospheric/Acidification	3.5	2	No
Agricultural nutrient surplus to coastal zones	Nutrient	3.3	2	No
Nutrient loading intensity	Nutrient	3.3	2	No
Nutrient discharge intensity	Intensity/Decoupling	3.6	2	No
Pollution-GDP decoupling factor	Intensity/Decoupling	3.6	2	No
Operational oil discharge from vessels	Hydrocarbon	3.3	2	No
Accidental oil spills	Hydrocarbon	3.3	2	No
Offshore operational discharge	Hydrocarbon	3.3	3	No
Antifouling compound release	Chemical	3.3	3	No
Estimated nitrogen deposition to marine waters	Atmospheric/Acidification	3.5	3	No
Maritime NOx emissions	Atmospheric/Acidification	3.5	3	No
Microplastic concentration	Marine Litter	3.4	3	No
Mercury emissions by sector	Atmospheric/Acidification	3.5	3	No

DRAFT

Indicator	Category	Section	Tier	FDES Core Set
Artisanal gold mining mercury use	Atmospheric/Acidification	3.5	3	No
Aquaculture emission intensity	Intensity/Decoupling	3.6	3	No
Coastal tourism waste intensity	Intensity/Decoupling	3.6	3	No
Land-based hydrocarbon runoff	Hydrocarbon	3.3	3	No

¶8 Countries at first implementation are recommended to compile all Tier 1 indicators before expanding to Tier 2 and Tier 3. Countries with partial monitoring infrastructure may selectively advance specific Tier 2 indicators where data are available without completing all Tier 1 indicators first, provided they document coverage gaps.

Indicator presentation and communication

¶1 The combined presentation table in Section 3.6 provides a template that can be adapted for dashboard and report card formats. Guidance on integrating pollution indicators with other ocean accounting outputs for combined presentation and communication is provided in **TG-3.8 Combined Presentations**.

6. Acknowledgements

¶1 **Authors:** Gerald Singh, Kirsten Oleson

¶2 **Reviewers:** [To be confirmed]

7. References

1. ¶1 United Nations, *Transforming Our World: The 2030 Agenda for Sustainable Development*, A/RES/70/1 (2015), Target 14.1.
2. ¶2 SEEA CF (2014), para. 6.116.
3. ¶3 Figure adapted from SEEA CF (2014), Chapter VI combined presentation approach, applied to marine pollution indicators.
4. ¶4 SEEA CF (2014), para. 6.145.
5. ¶5 United Nations, *Global indicator framework for the Sustainable Development Goals*, A/RES/71/313, Indicator 14.1.1.
6. ¶6 FDES 2013, Component 3: Residuals, paras. 3.162 onwards.
7. ¶7 FDES 2013, Chapter 1, paras. 1.39-1.44, on the Core Set of Environment Statistics.
8. ¶8 SEEA CF (2014), Table 3.18 on the structure of solid waste accounts by source and destination.
9. ¶9 SEEA CF (2014), Box 3.2 on household residuals; SEEA CF paras. 3.99-3.109 on attribution principles.
0. ¶10 OECD/Eurostat, *Gross Nitrogen Balances Handbook* (2007); OECD/Eurostat, *Gross Phosphorus Balances Handbook* (2007).
1. ¶11 FAO Land and Water Division, guidance on nutrient export coefficients for tropical agriculture (various editions).
2. ¶12 HELCOM, *Pollution Load Compilation* (most recent edition); OSPAR Commission, *Atmospheric deposition assessment* (most recent edition); EMEP Status Report 1/2024.
3. ¶13 Jambeck, J.R. et al., "Plastic waste inputs from land into the ocean," *Science* 347(6223) (2015): 768-771.
4. ¶14 Joint Committee for Guides in Metrology, *Evaluation of Measurement Data — Guide to the Expression of Uncertainty in Measurement* (GUM), JCGM 100:2008.
5. ¶15 FDES 2013, Topic 1.3.3: Marine water quality, paras. 3.58-3.66.
6. ¶16 SDG indicator 14.1.1: Index of coastal eutrophication and floating plastic debris density.
7. ¶17 FAO/UNSD, *System of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries (SEEA AFF)* (2018).
8. ¶18 FDES 2013, Subcomponent 3.4: Release of Chemical Substances, paras. 3.211-3.218.
9. ¶19 Regulation (EC) No 166/2006 concerning the establishment of a European Pollutant Release and Transfer Register.
0. ¶20 United Nations Environment Programme, *Guidance on Developing National Pollutant Release and Transfer Registers* (2006); UNEP Global PRTR (prtr.net).
1. ¶21 International Maritime Organization, Global Integrated Shipping Information System (GISIS), port reception facility module.

DRAFT

2. ¶22 International Maritime Organization, *International Convention for the Prevention of Pollution from Ships* (MARPOL), as amended.
3. ¶23 SDG indicator 14.1.1, floating plastic debris density component.
4. ¶24 UNEA Resolution 5/14, *End plastic pollution: towards an international legally binding instrument* (2022).
5. ¶25 Taskforce on Nature-related Financial Disclosures, *Recommendations of the Taskforce on Nature-related Financial Disclosures* (2023).
6. ¶26 Borrelle, S.B. et al., "Predicted growth in plastic waste exceeds efforts to mitigate plastic pollution," *Science* 369(6510) (2020): 1515-1518.
7. ¶27 Lau, W.W.Y. et al., "Evaluating scenarios toward zero plastic pollution," *Science* 369(6510) (2020): 1455-1461.
8. ¶28 GESAMP, *Sources, Fate and Effects of Microplastics in the Marine Environment*, Reports and Studies No. 90 (2015); SEEA CF (2014), para. 3.155 on dissolved/suspended substances.
9. ¶29 FAO, *Voluntary Guidelines on the Marking of Fishing Gear* (2019); FAO, *Technical Guidelines for Responsible Fisheries No. 13* on abandoned, lost or discarded fishing gear.
0. ¶30 UNWTO/UNSD, *Measuring the Sustainability of Tourism: A Statistical Framework* (SF-MST) (2024).
1. ¶31 SEEA Technical Note: Air Emissions Accounting (2016), Section 2.2.
2. ¶32 SEEA Technical Note: Air Emissions Accounting (2016), Core Account 1.
3. ¶33 SDG indicator 14.3.1: Average marine acidity (pH) measured at agreed suite of representative sampling stations.
4. ¶34 Minamata Convention on Mercury (2013), Article 8 (Emissions), Article 21 (Reporting).
5. ¶35 OECD, *Indicators to Measure Decoupling of Environmental Pressure from Economic Growth* (2002).
6. ¶36 SEEA CF (2014), para. 6.117.
7. ¶37 UNEP, *Decoupling Natural Resource Use and Environmental Impacts from Economic Growth* (2011).
8. ¶38 OECD, *Indicators to Measure Decoupling of Environmental Pressure from Economic Growth* (2002), Section 3; UNEP, *Decoupling Natural Resource Use* (2011), Chapter 4; EEA, *Decoupling of resource use and environmental impacts from economic growth*, EEA Report 2/2016.
9. ¶39 Adapted from SEEA CF (2014), Table 6.11: Combined presentation for air emissions.
0. ¶40 UN Environment Programme, *Measuring Progress: Environment and the SDGs* (2021).

DRAFT

Climate Change Indicators

Provides guidance on compiling climate change indicators from ocean accounts, addressing the nexus between ocean ecosystems and global climate systems.

Version 0.7.3 **Status** Draft **Stability** Applied

Last updated October 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

OUTCOME

DRAFT

This Circular provides guidance on compiling climate change indicators from ocean accounts, addressing the nexus between ocean ecosystems and global climate systems. Upon completing this Circular, readers will understand how to derive indicators for blue carbon sequestration and stocks from ecosystem accounts, compile ocean acidification indicators from condition accounts, calculate emission intensity indicators by ocean-related economic sector, and develop climate risk and adaptation indicators relevant to coastal and marine systems. The guidance integrates the carbon accounting frameworks of the System of Environmental-Economic Accounting Ecosystem Accounting (SEEA EA) with the air emissions accounting of the SEEA Central Framework (SEEA CF), supporting the Sustainable Development Goals (SDG 13: Climate Action and SDG 14: Life Below Water), nationally determined contributions (NDCs) under the Paris Agreement, Kunming-Montreal Global Biodiversity Framework Target 8 on minimising the impact of climate change on biodiversity, and the greenhouse gas disclosure requirements of sustainability standards including IFRS S2.

The indicators compiled through this Circular support four principal policy applications: (i) NDC tracking for ocean sectors — enabling countries to quantify the contribution of blue carbon ecosystems and offshore renewable energy to national climate commitments, and to assess the emission intensity of ocean-dependent industries relative to economy-wide targets; (ii) blue carbon accounting for REDD+ and related mechanisms — providing the physical flow and stock data required for carbon credit verification and monitoring of ecosystem-based mitigation projects; (iii) IFRS S2 corporate climate disclosure — supplying the sectoral emission intensity benchmarks and physical risk metrics that ocean-dependent companies require for Scope 1, 2, and 3 emissions reporting and transition risk assessment; and (iv) climate resilience planning — informing adaptation investments through indicators of coastal vulnerability, ecosystem-based adaptation deployment, and the protective services provided by marine ecosystems under climate scenarios.

This Circular builds on the aggregate indicator methodology in TG-2.1 Aggregate Biophysical Indicators, the asset accounting framework established in TG-3.1 Asset Accounts, and the residual flows accounting detailed in TG-3.4 Flows from Economy to Environment. It enables the policy integration addressed in TG-1.4 OA and Sustainable Ocean Planning.

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 4
3.1 Ocean-Climate Indicator Framework 4
3.2 Blue Carbon Indicators 7
3.3 Ocean Acidification Indicators 11
3.4 Emission Intensity Indicators 13
3.5 Climate Risk and Adaptation Indicators 16
3.6 Worked Example: Ocean Sector GHG Emission Intensity 18
4. Acknowledgements 21
5. References 21

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Climate Change Indicators (2026) (GOAP Technical Guidance on Ocean Accounting, TG-2.8, v0.7.3). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-2/2-8-climate-indicators/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

¶1 **Framework Position**

¶2 TG-2.8 is a member of the Section 2 indicators family, which provides guidance on deriving policy-relevant statistics from the physical and monetary accounts compiled in Sections 3 and 4. Within that family, this Circular addresses the climate change dimension of ocean accounting: it compiles blue carbon, acidification, emission intensity, and climate risk indicators that are distinct from — but complementary to — the aggregate biophysical indicators in **TG-2.1 Aggregate Biophysical Indicators** and the disaster risk indicators in **TG-2.9 Disaster Risk Indicators**. Compilers should read TG-2.1 before this Circular for the general methodology of deriving normalised indicators from ecosystem condition accounts.

1. Outcome

¶1 This Circular provides guidance on compiling climate change indicators from ocean accounts, addressing the nexus between ocean ecosystems and global climate systems. Upon completing this Circular, readers will understand how to derive indicators for blue carbon sequestration and stocks from ecosystem accounts, compile ocean acidification indicators from condition accounts, calculate emission intensity indicators by ocean-related economic sector, and develop climate risk and adaptation indicators relevant to coastal and marine systems. The guidance integrates the carbon accounting frameworks of the System of Environmental-Economic Accounting Ecosystem Accounting (SEEA EA)[1] with the air emissions accounting of the SEEA Central Framework (SEEA CF)[2], supporting the Sustainable Development Goals (SDG 13: Climate Action and SDG 14: Life Below Water)[3], nationally determined contributions (NDCs) under the Paris Agreement[4], Kunming-Montreal Global Biodiversity Framework Target 8 on minimising the impact of climate change on biodiversity[5], and the greenhouse gas disclosure requirements of sustainability standards including IFRS S2[6].

¶2 The indicators compiled through this Circular support four principal policy applications: (i) **NDC tracking for ocean sectors** — enabling countries to quantify the contribution of blue carbon ecosystems and offshore renewable energy to national climate commitments, and to assess the emission intensity of ocean-dependent industries relative to economy-wide targets; (ii) **blue carbon accounting for REDD+ and related mechanisms** — providing the physical flow and stock data required for carbon credit verification and monitoring of ecosystem-based mitigation projects; (iii) **IFRS S2 corporate climate disclosure** — supplying the sectoral emission intensity benchmarks and physical risk metrics that ocean-dependent companies require for Scope 1, 2, and 3 emissions reporting and transition risk assessment; and (iv) **climate resilience planning** — informing adaptation investments through indicators of coastal vulnerability, ecosystem-based adaptation deployment, and the protective services provided by marine ecosystems under climate scenarios.

¶3 This Circular builds on the aggregate indicator methodology in **TG-2.1 Aggregate Biophysical Indicators**, the asset accounting framework established in **TG-3.1 Asset Accounts**, and the residual flows accounting detailed in **TG-3.4 Flows from Economy to Environment**. It enables the policy integration addressed in **TG-1.4 OA and Sustainable Ocean Planning**.

2. Requirements

¶1 This Circular requires familiarity with:

- ¶2 **TG-0.1 General Introduction to Ocean Accounts** — for the conceptual framework and key components of Ocean Accounts
- ¶3 **TG-0.2 Overview of Relevant Statistical Standards** — for the methodological foundations provided by SNA 2025, SEEA CF, and SEEA EA
- ¶4 **TG-2.1 Aggregate Biophysical Indicators** — for the general methodology of deriving normalised indicators and composite indices from ecosystem condition accounts

DRAFT

- ¶5 **TG-3.4 Flows from Economy to Environment** — for the framework of air emissions accounts and attribution of residual flows to economic sectors

3. Guidance Material

¶1 Oceans are central to the global climate system, absorbing more than 90 per cent of excess heat and about 25 per cent of anthropogenic carbon dioxide emissions[7]. Marine ecosystems provide climate mitigation services through carbon sequestration. The same ecosystems experience climate-driven changes including warming, acidification, and altered circulation patterns. Ocean accounts provide a systematic framework for measuring these ocean-climate interactions, enabling compilation of indicators that track both the climate services provided by marine ecosystems and the climate pressures affecting them.

¶2 This Circular compiles blue carbon, acidification, emission intensity, and climate risk indicators from ocean accounts, spanning five thematic areas described in the sections below.

3.1 Ocean-Climate Indicator Framework

¶1 This framework distinguishes between indicators that measure the role of oceans in climate regulation (mitigation-related) and indicators that measure climate impacts on ocean systems (vulnerability and adaptation-related). Figure 2.8.1 illustrates how the ocean-climate system anchors three complementary reporting pathways — mitigation, vulnerability, and emission intensity — and maps the indicators in each to their downstream international reporting obligations.

DRAFT

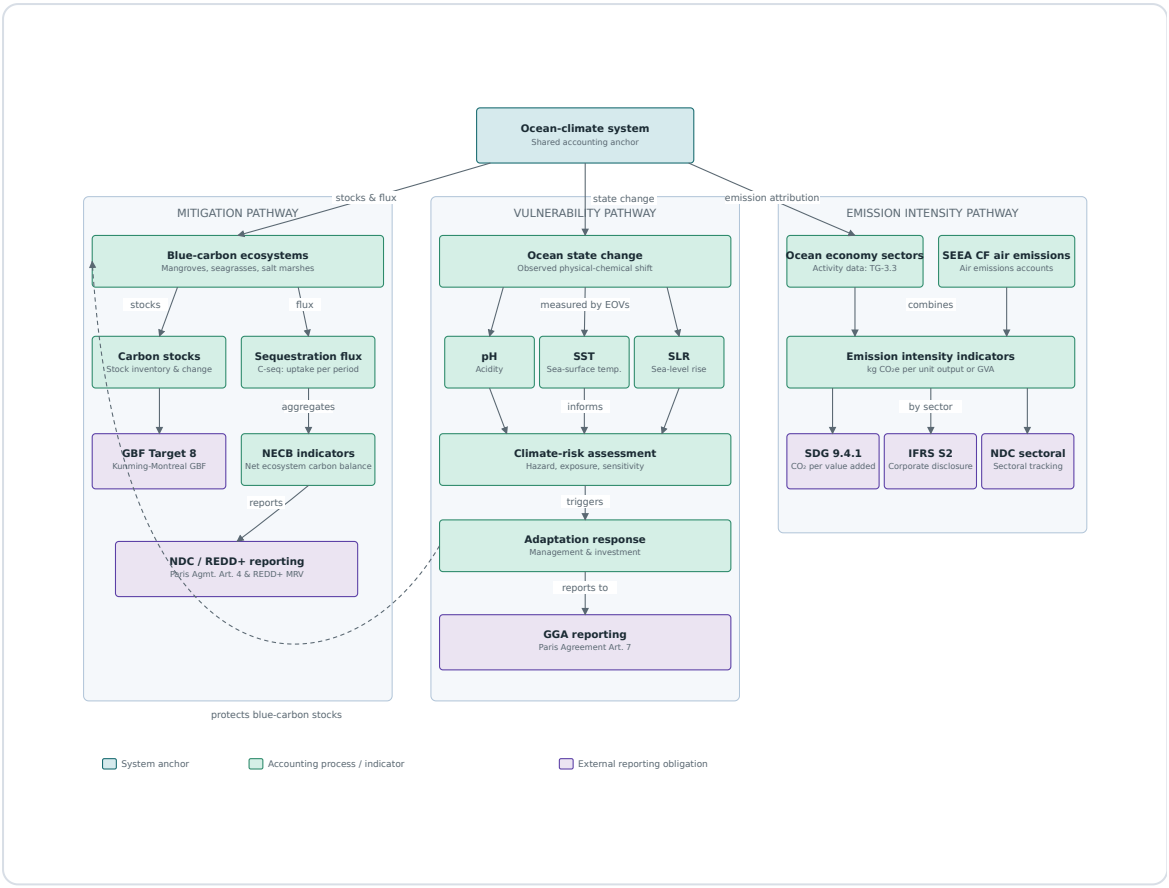


Figure 2.8.1 The ocean-climate framework links mitigation, vulnerability, and emission-intensity pathways from accounts to indicators. Vulnerability pathway uses pH, SST, and sea-level rise EOVs; intensity pathway combines TG-3.3 activity with SEEA CF air emissions.

Source: TG-2.8 draft v7; Paris Agreement Articles 4 and 7; Kunming-Montreal GBF Target 8 (2022); SEEA CF (air emissions accounts); SEEA EA Chapter 13 (carbon stock accounts).

Adapted from: IOC-GOOS Essential Ocean Variables specification sheets; IPCC SROCC Chapter 5 (oceans and coastal ecosystems).

DRAFT

Indicator categories

¶1 Climate change indicators derived from ocean accounts can be organised into the four principal categories summarised in Table 3.1.1 below[8].

Category	Description
Carbon flux indicators	Measuring the exchange of carbon between the atmosphere and ocean ecosystems, including sequestration by blue carbon ecosystems (mangroves, seagrasses, salt marshes) and carbon uptake by open ocean systems.
Carbon stock indicators	Measuring the standing stock of carbon held in marine and coastal ecosystems, representing the climate mitigation capacity that would be released if ecosystems were degraded.
Ocean state indicators	Measuring physical and chemical changes in ocean conditions attributable to climate change, including temperature, pH, dissolved oxygen, and sea level.
Emission attribution indicators	Measuring the greenhouse gas emissions associated with ocean-related economic activities, supporting analysis of emission intensity and transition pathways.

¶2 This four-category structure does not separately distinguish adaptation effectiveness indicators from ocean state indicators. Whilst the UNFCCC Global Goal on Adaptation (GGA) framework is developing dedicated metrics for adaptation effectiveness, the indicators in this Circular that relate to adaptation outcomes, such as nature-based solution deployment and coastal protection services (Section 3.5), are compiled from the same condition and extent accounts as the ocean

state indicators. As the GGA indicator framework matures, compilers may disaggregate adaptation effectiveness as a distinct reporting category whilst maintaining the underlying accounting structure described here.

Ocean-climate indicator-account alignment table

Outputs and use cases

¶1 Table 1a maps each major indicator type to its unit of measure, the account it populates, its downstream reporting framework, the typical institutional recipient, and a key caveat. This table is intended as a navigation aid for multi-agency compilation teams to prevent misrouting of outputs across reporting frameworks.

¶2 **Table 1a: Outputs and Use Cases**

Indicator	Unit	Account Type	Reporting Framework	Institutional Recipient	Key Caveat
Annual carbon sequestration rate	tCO2e/ha/yr	Physical flow — service supply	Paris Agreement; REDD+	Ministry of Environment / UNFCCC focal point	SEEA EA service flow; not a direct GHG inventory removal
Total ecosystem carbon stock	tC/ha	Carbon stock account	GBF Target 8	NSO / biodiversity ministry	Physical units; monetary valuation requires shadow price (see Section 3.2)
Carbon stock change	tC/yr	Carbon stock account	GBF Target 8; REDD+ verification	NSO / REDD+ national authority	Distinct from inventory removals; pool-specific emission factors required for inventory use
Ocean pH	pH units	Condition account	SDG 14.3.1	NSO / IOC-UNESCO focal point	Satellite-derived estimates are provisional; in situ preferred for SDG reporting
Aragonite saturation state	omega-a	Condition account	SDG 14.3.1 (supplementary)	NSO / oceanographic agency	Requires full carbonate system measurement
GHG emission intensity by ocean sector	kg CO2e per tonne output or per 1,000 currency units GVA	Air emissions / supply-use hybrid	SDG 9.4.1; NDC sectoral tracking	NSO / climate ministry	Scope 1 only from SEEA CF; Scope 2 and 3 require supplementary modelling[9]
Sea level rise exposure	ha exposed	Extent / condition account	GGA (in development)	Disaster risk / coastal planning agency	Scenario-dependent; align with national sea level projections

DRAFT

Indicator	Unit	Account Type	Reporting Framework	Institutional Recipient	Key Caveat
Marine heatwave frequency	days/yr	Condition account	GGA (in development)	NSO / meteorological service	Heatwave definition must follow agreed climatological threshold
NbS deployment area	ha	Extent account	GBF Target 8; GGA (in development)	NSO / biodiversity ministry	Track gross restoration; deduct losses for net assessment

Links to international frameworks

¶1 Ocean-climate indicators support multiple international monitoring and reporting frameworks. SDG indicator 14.3.1 directly addresses ocean acidification [10]; SDG 13 indicators on climate action are supported by emission intensity data and climate risk assessments derived from ocean accounts. National GHG inventories include emissions and removals from coastal wetlands under the AFOLU sector, using IPCC Wetlands Supplement methodologies [11], and many countries now reference ocean-based mitigation and adaptation measures in their NDCs [12]. GBF Target 8 calls on parties to minimise the impact of climate change and ocean acidification on biodiversity through nature-based solutions [5], and the TNFD framework identifies climate-nature linkages as a priority area, with explicit attention to blue carbon ecosystems [13].

Spatial and temporal considerations

¶1 Ocean-climate indicators require careful attention to spatial and temporal boundaries:

- ¶2 **Spatial scope**: Indicators should align with the marine spatial framework established in **TG-0.1 General Introduction**, distinguishing between coastal waters, the Exclusive Economic Zone (EEZ), and where relevant, high seas areas and seabed beyond national jurisdiction
- ¶3 **Temporal resolution**: Climate-relevant indicators may require annual or multi-year compilation periods, with attention to interannual variability in carbon fluxes and oceanographic conditions
- ¶4 **Reference conditions**: Changes in ocean state should be assessed against appropriate baselines, acknowledging that pre-industrial reference conditions may not be directly observable and must be estimated from historical data or models. The approach to reference conditions should follow the general methodology described in **TG-2.1** Section 3.4.2

3.2 Blue Carbon Indicators

¶1 Blue carbon refers to the carbon captured and stored by coastal and marine ecosystems, particularly mangroves, tidal salt marshes, and seagrass meadows [14]. These ecosystems are exceptionally efficient carbon sinks, sequestering carbon at rates two to four times greater than terrestrial forests per unit area and storing carbon in sediments for millennia under undisturbed conditions [15]. Ocean accounts provide the framework for measuring blue carbon stocks and flows, enabling compilation of indicators for climate mitigation policy and carbon market mechanisms.

¶2 The blue carbon indicators in this section are closely related to the ecosystem service measurements in **TG-6.2 Mangrove and Coastal Wetland Accounting**, which addresses blue carbon services in detail. In particular, TG-6.2 Section 3.3 (Blue Carbon Services) describes the service measurement approaches from which several indicators below are derived. The carbon sequestration rate indicator corresponds to the regulating service flow recorded in ecosystem service supply tables; the carbon stock indicator corresponds to the carbon stock account in the asset balance sheet; and the carbon retention indicator corresponds to the ongoing service of maintaining exist-

DRAFT

ing stocks. Compilers should consult TG-6.2 for the detailed accounting methodology underlying these indicators.

Carbon sequestration indicators

¶1 Carbon sequestration indicators measure the rate at which blue carbon ecosystems remove carbon dioxide from the atmosphere and transfer it to long-term storage. Key indicators include:

¶2 **Annual carbon sequestration rate** (tonnes CO2 equivalent per hectare per year): The net carbon uptake (net ecosystem carbon balance, NECB) by blue carbon ecosystems, recorded as a regulating service flow.

¶3 The SEEA EA framework for ecosystem services recognises carbon sequestration as a regulating service, recording the net ecosystem carbon balance as the measure of service supply[16]. For ocean accounting, this service flow should be recorded by ecosystem type and spatial unit, enabling attribution to specific marine areas and ecosystem assets.

¶4 **Carbon balance concepts — NECB, NEP, and NBP.** The target concept for the sequestration rate formula above is the net ecosystem carbon balance (NECB) — the quantity recorded as a regulating service flow in SEEA EA physical flow accounts (paragraphs 6.110–6.113). Compilers should distinguish NECB from two related but non-equivalent concepts. Net ecosystem production (NEP) excludes lateral carbon export losses (dissolved organic carbon, particulate organic carbon transported to adjacent systems), and will overestimate NECB where lateral exports are significant. Net biome production (NBP) additionally deducts carbon losses from disturbance events (fire, pest outbreaks, harvesting); NBP is the appropriate concept for landscape-scale GHG inventory reporting but is more restrictive than the SEEA EA service flow concept.

¶5 When applying Tier 1 IPCC default sequestration rates from the 2013 Wetlands Supplement, compilers should consult the relevant methodology chapter (particularly Section 2.3 for generic wetland concepts and Chapter 4 for coastal wetlands) to confirm which carbon balance concept the default rates represent, and adjust if necessary. Study designs underlying the defaults vary: some approximate NECB through long-term sediment accumulation measurements, whilst others measure NEP or NBP. Applying a NECB formula to input data derived from NBP studies will produce a systematic underestimate.

DRAFT

¶6 **Ecosystem-specific sequestration rates**: Compilation should distinguish sequestration by ecosystem type, recognising substantial variation in rates:

- ¶7 Mangroves: 6-8 tonnes CO2 per hectare per year
- ¶8 Salt marshes: 5-8 tonnes CO2 per hectare per year
- ¶9 Seagrass meadows: 1.5-3 tonnes CO2 per hectare per year[17]

¶10 These indicative ranges represent net ecosystem carbon balance (NECB) estimates, consistent with long-term sediment carbon accumulation rates. They should not be compared to gross primary production values without first subtracting respiration and export terms as specified in the formula above.[18]

¶11 These rates vary substantially with ecosystem condition, latitude, and local environmental conditions, and should be derived from local measurements or regionally calibrated estimates where available. Uncertainty in sequestration rate estimates is substantial, and compilers should document it following the guidance in the 2013 IPCC Wetlands Supplement[11]. Uncertainty quantification is particularly important when estimates are used for carbon credit verification or national inventory reporting, where the confidence interval directly affects the credibility of reported removals.

¶12 **National blue carbon sequestration**: The aggregate carbon sequestration across all blue carbon ecosystems within national marine areas, expressed in tonnes CO2 equivalent per year. This indicator supports national climate reporting and assessment of nature-based solutions to climate change.

¶13 **Relationship to National GHG Inventory Reporting**

¶14 Blue carbon sequestration compiled as a SEEA EA regulating service flow and coastal wetland removals reported in the national GHG inventory (IPCC AFOLU sector) are related but distinct estimates produced by different processes.

¶15 **Conceptual mapping.** The SEEA EA service flow account records the net ecosystem carbon balance (NECB) as a physical flow in tonnes of carbon per accounting period. The IPCC inventory, by contrast, requires activity data (land area by management category) plus emission factors (from the 2013 Wetlands Supplement, Tier 1–3) to produce a removals estimate in CO2-equivalent tonnes. These inputs are not interchangeable: physical stock totals from ocean accounts cannot be directly submitted to the inventory without conversion using the appropriate activity-data and emission-factor framework.

¶16 **Use of the two estimates.** How the account estimate and the inventory estimate are reconciled, which of them governs for crediting, and how the compiling agencies coordinate are decision-use questions outside the scope of this Circular.

Spatial boundary protocol for submerged habitat stocks

¶1 Compilers assembling carbon stock totals for submerged blue carbon ecosystems — particularly seagrass meadows, which are frequently located on the continental shelf beyond national land registries — should apply the following spatial boundary rules.

¶2 The **Exclusive Economic Zone (EEZ) boundary** governs inclusion of submerged habitat stocks in the national account. Coastal State sovereign rights over natural resources in the EEZ are established under UNCLOS Part V (Articles 55–75)[19], providing the legal basis for including stocks in submerged lands throughout the EEZ, even where those areas are not registered in national land cadastres.

¶3 Where maritime boundaries are subject to **overlapping claims or joint jurisdiction**, compilers should note the relevant spatial units as disputed in the compilation metadata and document the boundary assumptions applied. The treatment of stocks in disputed areas should follow any applicable bilateral or multilateral agreement; where no such agreement exists, compilers should disclose the boundary assumption and avoid making unilateral allocation decisions in the published accounts.

¶4 For remote sensing approaches to mapping submerged habitats in outer EEZ contexts, including areas not covered by coastal mapping surveys, see **TG-4.1 Remote Sensing**. For small island developing states (SIDS) with large EEZs relative to land area, submerged seagrass stocks may represent the majority of national blue carbon assets; applying adequate remote sensing coverage is particularly important in these contexts.

Carbon stock indicators

¶1 Carbon stock indicators measure the accumulated carbon held in blue carbon ecosystem pools, representing both the climate mitigation asset and the emission liability if ecosystems are degraded.

¶2 **Total ecosystem carbon stock** (tonnes carbon per hectare): The carbon stored across all pools within the ecosystem, comprising:

- ¶3 Aboveground biomass (trees, shrubs, vegetation)
- ¶4 Belowground biomass (roots)
- ¶5 Dead organic matter (litter, dead wood)
- ¶6 Soil organic carbon (the largest pool, often extending metres deep in coastal sediments)

¶7 The SEEA EA carbon stock account provides the accounting structure for recording these stocks by ecosystem type and tracking changes between accounting periods[20]. Table 13.3 of SEEA EA presents the structure of carbon stock accounts, disaggregating stocks into geocarbon, biocarbon, carbon in the economy, carbon in the oceans, and carbon in the atmosphere.

DRAFT

¶8 **Ecosystem carbon stock by type**: Carbon stocks should be compiled separately for each blue carbon ecosystem type, recognising substantial variation:

- ¶9 Mangroves: approximately 1,000-1,500 tonnes carbon per hectare (including deep sediments)
- ¶10 Salt marshes: approximately 200-400 tonnes carbon per hectare
- ¶11 Seagrass meadows: approximately 100-300 tonnes carbon per hectare [21]

¶12 **Carbon stock change indicators**: Changes in ecosystem carbon stocks between accounting periods provide indicators of net carbon accumulation or release:

- ¶13 Increase in carbon stocks (positive) indicates net carbon removal from atmosphere
- ¶14 Decrease in carbon stocks (negative) indicates net carbon emission to atmosphere

¶15 Stock changes may result from ecosystem extent changes (conversion, restoration), condition changes (degradation, improvement), or natural dynamics. The SEEA EA framework for ecosystem condition accounts enables tracking of the drivers of stock change. When blue carbon ecosystems are converted or degraded, not all stored carbon is released immediately. Decay rates vary by pool: aboveground biomass may decompose within years, whilst deep sediment carbon may remain stable for decades or longer depending on the nature of the disturbance. Compilers should apply pool-specific emission factors that reflect these differential release rates, drawing on the guidance in Chapter 4 of the IPCC 2013 Wetlands Supplement [22] and, where available, locally calibrated emission factors. This distinction is particularly important for policy analyses comparing the climate impact of different types of ecosystem degradation.

Carbon retention services

¶1 Beyond annual sequestration, blue carbon ecosystems provide carbon retention services by maintaining existing carbon stocks that would otherwise be released to the atmosphere [23]. This service concept recognises that:

- ¶2 Ecosystems with high carbon stocks (such as old-growth mangroves) provide high retention value even if their current sequestration is low due to equilibrium conditions
- ¶3 Degradation or conversion of carbon-rich ecosystems results in substantial emissions
- ¶4 The retention service is an ongoing service flow, distinct from the one-time sequestration that accumulated the stock

¶5 SEEA EA provides guidance on valuing carbon retention services using the annuity approach, which spreads the value of the carbon stock across expected future periods [24]. This approach sends appropriate policy signals regarding the importance of conserving existing blue carbon stocks.

DRAFT

¶6 **Carbon price assumption for retention service valuation**

¶7 Monetary valuation of carbon retention services using the annuity approach (SEEA EA Annex A12.1) requires a shadow price or social cost of carbon as a key parameter. Published estimates of the social cost of carbon span a wide range — from approximately USD 15 to over USD 400 per tonne CO2 depending on discount rate, damage function, and equity weighting — and NSOs are unlikely to have a nationally agreed value established for statistical purposes.

¶8 Compilers should apply the following hierarchy:

1. ¶9 **National or ETS price**: Where the country has adopted a formal carbon price (emissions trading scheme or carbon tax), use this price as the primary assumption for comparability with national policy valuations.
2. ¶10 **Stern-Stiglitz benchmark**: Where no national price exists, use the High-Level Commission on Carbon Prices benchmark of USD 40–80 per tonne CO2 by 2020, rising to USD 50–100 per tonne CO2 by 2030 (in 2015 USD terms), as an internationally recognised reference value. [25]
3. ¶11 **Sensitivity range**: Regardless of the price chosen, report the monetary valuation result alongside an explicit sensitivity range — at minimum, results using the lower and upper bounds of the adopted price range. This is essential for reproducibility and cross-country comparability.
4. ¶12 **Physical stock as primary indicator**: Consider reporting the physical stock estimate (tonnes carbon per hectare) as the primary indicator, with the monetary valuation as a supplementary figure. The physical stock is methodologically unambiguous; the monetary value is a policy construct that depends on contested parameters.

Data sources and compilation

¶1 Blue carbon indicators require integration of multiple data sources, as summarised in Table 3.2.1 below.

Data Source	Description
Extent data	Remote sensing products for mangrove, salt marsh, and seagrass distribution, including the Global Mangrove Watch [26] for standardised mangrove extent mapping and the Allen Coral Atlas for reef-associated habitat mapping. Detailed methodology for remote sensing-based extent compilation is provided in **TG-4.1 Remote Sensing**.
Carbon density estimates	From field sampling, literature synthesis, or ecosystem models.
Flux measurements	From eddy covariance towers, sediment cores, or modelled estimates.
Stock-change detection	From repeated extent mapping and condition assessment.

DRAFT

¶2 The IPCC Guidelines for National Greenhouse Gas Inventories and the 2013 Wetlands Supplement provide Tier 1 default values for carbon stocks and sequestration rates that can be applied where local data are unavailable [27]. These global datasets are particularly important for countries with limited national monitoring capacity, providing a baseline from which national estimates can be progressively refined as local data become available.

3.3 Ocean Acidification Indicators

¶1 Ocean acidification reduces seawater pH through absorption of anthropogenic carbon dioxide, with significant ecological and economic consequences [28]. The SEEA EA framework for ecosystem condition accounts provides the structure for recording pH and related carbonate chemistry variables as condition indicators, supporting compilation of ocean acidification indicators for climate monitoring and policy.

pH-based indicators

¶1 **Mean surface ocean pH**: The average pH of surface ocean waters within the accounting area, measured at representative sampling stations. SDG indicator 14.3.1 specifies this measurement approach, requiring pH data from an agreed suite of representative sampling stations [29].

¶2 **pH change from reference period**: The change in mean pH relative to a baseline period (typically pre-industrial or a specified reference decade). Given the logarithmic pH scale, a decrease of

0.1 pH units represents approximately a 26 per cent increase in hydrogen ion concentration.

¶3 **Aragonite saturation state**: The saturation state of calcium carbonate minerals, particularly aragonite, which is essential for shell-forming organisms including corals, molluscs, and some plankton [30] . Aragonite saturation (omega-a) below 1.0 indicates undersaturation and corrosive conditions for calcifying organisms.

¶4 **Seasonal pH variability**: The range and timing of pH variation within the accounting period, important for understanding biological exposure to acidification stress.

¶5 Measurement precision and accuracy are central considerations for pH-based indicators. Spectrophotometric pH measurements typically achieve precision of plus or minus 0.001 pH units, whilst electrode-based measurements may be an order of magnitude less precise. The Global Ocean Acidification Observing Network (GOA-ON) best practices guide [31] provides detailed quality assurance guidance for acidification observations, including requirements for certified reference materials, inter-laboratory comparisons, and metadata documentation. Compilers should document the measurement methods and associated uncertainty for all pH-based indicators to support comparability across stations and time periods.

Data adequacy for national reporting

¶1 Before using pH observations for national SDG 14.3.1 or ocean account reporting, compilers should assess whether their observing network meets adequacy criteria for the intended use.

¶2 **GOA-ON coverage recommendations.** The GOA-ON Requirements and Governance Plan [31] provides station coverage recommendations distinguishing **coastal** representativeness (sufficient stations to capture nearshore gradients driven by upwelling, river inputs, and biological activity) from **open ocean** representativeness (sufficient spatial coverage within the EEZ to characterise offshore conditions). Countries should consult Section 3 of the GOA-ON Requirements document for specific guidance applicable to their oceanographic context.

¶3 **Sparse network protocol.** Countries with fewer stations than the applicable GOA-ON threshold must: (a) Report the pH indicator with a coverage caveat specifying the share of the EEZ represented by in situ observations. (b) Disclose their reliance on global gridded products — such as SOCAT v2024 (surface ocean CO2 atlas) or GLODAPv2 (interior ocean carbon data) — to supplement the sparse national network, including the version of the product used and the spatial cells applied.

¶4 **Satellite-derived estimates.** Satellite-based pH estimation algorithms offer spatial coverage for data-scarce countries but carry substantially higher uncertainty than in situ spectrophotometric measurement (typically ±0.1–0.3 pH units for current algorithms versus ±0.001 for in situ). Before using satellite-derived pH estimates for SDG 14.3.1 reporting, compilers should consult the IOC-UNESCO custodian agency guidance on acceptable data sources for this indicator. Where satellite estimates are used, compilers must: (a) Disclose the algorithm used and its root-mean-square error (RMSE) against available in situ validation data. (b) Report the uncertainty of the satellite-derived estimate alongside the indicator value. (c) Classify the satellite-based estimate as **provisional** in the national ocean accounts metadata, with a documented plan for progressive validation improvement as in situ capacity develops.

¶5 Satellite estimates are appropriate as provisional data for spatial pattern analysis and for countries with no in situ capacity. They should not be treated as equivalent to in situ measurements for SDG reporting unless the IOC-UNESCO custodian agency has issued guidance confirming their acceptability. [32]

Spatial distribution indicators

¶1 Ocean acidification varies substantially with location, creating spatial patterns that are important for ecosystem impact assessment:

DRAFT

- ¶2 **Coastal vs. open ocean**: Coastal waters may experience more extreme pH variation due to upwelling, river inputs, and biological activity
- ¶3 **Depth gradients**: pH generally decreases with depth, with acidification effects most pronounced in deeper waters
- ¶4 **Regional patterns**: Some regions (high latitudes, upwelling zones) experience accelerated acidification

¶5 Condition accounts should record pH and acidification indicators at appropriate spatial resolution to capture these patterns.

Ecosystem impact indicators

¶1 The ecological significance of acidification depends on the sensitivity of resident organisms and ecosystems. Mapping these impacts to the SEEA EA ecosystem condition typology strengthens integration with broader condition accounting:

¶2 **Coral calcification impact**: Reduced calcification rates in reef-building corals, measurable through growth rates, skeletal density, and reef accretion rates. Within the SEEA EA condition typology, this maps to the "ecosystem structural state" characteristic, reflecting changes in the physical structure of the reef ecosystem. This indicator links to the coral reef condition assessment in **TG-6.1 Coral Reef Accounts**.

¶3 **Shellfish production impact**: Effects on commercially important molluscs and crustaceans, potentially measurable through aquaculture production data or wild stock assessments. This maps to the "species-based characteristics" of ecosystem condition, specifically the abundance and productivity of calcifying species.

¶4 **Pteropod shell condition**: Pteropods (swimming snails) are sentinel organisms for acidification, with shell dissolution providing an early warning indicator of ecosystem stress. Within the condition typology, pteropod shell condition serves as a "species-based characteristic" indicator of the chemical dimension of ecosystem condition.

DRAFT

Data sources and compilation

¶3 Ocean acidification indicators require specialised oceanographic measurements:

- ¶4 **Fixed monitoring stations**: Time-series stations with continuous or regular pH measurement
- ¶5 **Research vessel surveys**: Periodic hydrographic surveys with carbonate chemistry analysis
- ¶6 **Autonomous platforms**: Profiling floats, gliders, and moorings with pH sensors
- ¶7 **Satellite-derived estimates**: Algorithms relating sea surface temperature and other observable variables to pH (see data adequacy section above for fitness-for-purpose criteria)

¶8 The Global Ocean Acidification Observing Network (GOA-ON) provides coordination and data access for acidification monitoring that can support national compilation [31].

3.4 Emission Intensity Indicators

¶1 Emission intensity indicators link greenhouse gas emissions to economic activity, enabling assessment of the carbon footprint of ocean-related industries and tracking of decarbonisation progress. These indicators combine the air emissions accounts of the SEEA CF with the economic activity data described in **TG-3.3 Economic Activity Relevant to the Ocean**. The SEEA CF air emissions account methodology attributes emissions to the economic unit responsible for the direct release, which corresponds to Scope 1 emissions in the GHG Protocol terminology [33]. The SNA 2025 reinforces this treatment through its framework for recording residual flows from the economy to the environment, providing the national accounting basis for emission attribution [34].

Compilation procedure for ocean sector emission intensity

¶1 The derivation of emission intensity indicators from ocean accounts follows a structured procedure:

¶2 **Step 1: Extract emissions data by industry** — From the air emissions account compiled under **TG-3.4 Flows from Economy to Environment**, identify the rows corresponding to ocean-related industries (fishing, aquaculture, maritime shipping, offshore energy, coastal tourism) using the ISIC concordance from **TG-3.3** Table 2. Record the tonnes of CO2-equivalent emissions attributed to each industry for the accounting period.

¶3 **Step 2: Extract activity data by industry** — From the ocean economy supply and use tables compiled under TG-3.3, extract the corresponding denominators: tonnes of production (for fishing and aquaculture), tonne-kilometres of freight (for shipping), units of energy produced (for offshore energy), or visitor-days (for coastal tourism). Alternatively, use gross value added (GVA) in monetary units as a common denominator across industries.

¶4 **Step 2a: Verify temporal alignment** — Confirm that the emissions data from Step 1 and the activity data from Step 2 refer to the same reference year. National air emissions accounts are often published two to three years after the reference year, whilst fisheries landings data and aquaculture production figures may follow different reporting cycles (harvest year versus calendar year). Where a data lag prevents alignment, the compiler must either (a) interpolate the lagged series using a documented methodology and record the interpolation approach in the indicator metadata, or (b) publish the indicator with a metadata mismatch flag in accordance with the quality disclosure framework in **TG-0.7 Quality Assurance**, specifying which data element relates to a different year and the direction of likely bias. Where fuel prices have fallen and fleet size is stable, lagged emissions data are likely to overstate current-year intensity (upward bias); where fleet expansion is ongoing, they may understate it (downward bias). Compilers should document the relevant trend direction in the indicator metadata. Silently mixing reference years is not acceptable.[35]

¶5 **Step 3: Calculate intensity ratios** — Divide the emissions (Step 1) by the activity measure (Step 2) to derive the emission intensity for each industry. Express the result in appropriate units: kg CO2e per tonne of fish landed, g CO2e per tonne-kilometre, kg CO2e per unit of energy, or kg CO2e per visitor-day. For GVA-based intensity, express as kg CO2e per thousand currency units of value added.

¶6 **Step 4: Disaggregate by sub-industry where feasible** — Where data permit, disaggregate intensity indicators by gear type (for fishing), vessel class (for shipping), fuel type (for offshore energy), or tourism segment (for coastal tourism). This disaggregation enables more targeted policy analysis and identification of transition opportunities.

¶7 **Step 5: Compile time series** — Repeat Steps 1-4 for successive accounting periods to construct a time series showing trends in emission intensity. Declining intensity over time indicates relative decoupling of emissions from economic activity, a key indicator of progress toward climate targets.

¶8 **Step 6: Document data sources and assumptions** — For each indicator, record the data sources for both the numerator (emissions) and denominator (activity), document any estimation methods or proxies used, and note any discontinuities in the time series due to methodological changes. This documentation is essential for quality assurance per **TG-0.7 Quality Assurance**.

Industry emission intensity

¶1 **GHG emissions per unit of output** (kg CO2 equivalent per unit of production or value added): The greenhouse gas intensity of specific ocean-related industries, enabling comparison across sectors and tracking over time. Table 2 maps the ocean industries referenced in this section to ISIC Rev.4 codes, following the classification established in **TG-3.3** Section 3.3.

¶2 **Table 2: Ocean Industry Emission Intensity — ISIC Rev.4 Mapping**

DRAFT

Ocean Industry	ISIC Rev.4	Indicator Unit	Note
Marine fishing	0311, 0312	kg CO2e per tonne of landed catch	
Aquaculture	0321, 0322	kg CO2e per tonne of production	
Maritime shipping	5011, 5012	g CO2e per tonne-kilometre	
Offshore energy (fossil)	0610, 0620	kg CO2e per unit of energy produced	
Offshore energy (renewable)	3510 (partial) [36]	kg CO2e per unit of energy produced	Identification of the offshore renewable subset requires supplementary data from energy statistics or licensing records
Coastal tourism	5510, 9319 (partial)	kg CO2e per visitor-day	

¶3 Table 3.4.1 below summarises industry-specific considerations for emission intensity indicators.

Industry	Considerations
Fishing industry	Emissions per tonne of landed catch or per unit of fish biomass provisioning service. Fuel combustion is the primary emission source, with intensity varying substantially by gear type and target species. For detailed guidance on fisheries accounting, see **TG-6.7 Fisheries Accounting: Integrating Stock Assessment**.
Aquaculture	Emissions per tonne of production, including both direct emissions (fuel, heating) and embedded emissions in feed and other inputs.
Maritime shipping	Emissions per tonne-kilometre of freight or per passenger-kilometre, following IMO methodologies [37] .
Offshore energy	Emissions per unit of energy produced, distinguishing between fossil fuel extraction and renewable energy generation. For detailed guidance, see **TG-6.9 Offshore Energy**.
Coastal tourism	Emissions per visitor-day or per unit of tourism expenditure.

¶4 SDG indicator 9.4.1 (CO2 emission per unit of value added) provides the general methodology for industry emission intensity that can be applied to ocean sectors [38] .

Scope 1, 2, and 3 emissions

¶1 Following the IFRS S2 framework for climate disclosure, emission intensity indicators should distinguish between the scopes summarised in Table 3.4.2 below. [39]

Scope	Description
Scope 1	Direct emissions from owned or controlled sources (e.g., vessel fuel combustion, facility operations).
Scope 2	Indirect emissions from purchased electricity, steam, heating, and cooling.
Scope 3	All other indirect emissions in the value chain, including upstream (fuel production, equipment manufacture) and downstream (product use, end-of-life treatment).

¶2 For ocean-related industries, Scope 3 emissions are often substantial: in aquaculture, for example, emissions from feed production may exceed direct operational emissions. However, compilers should note that the SEEA CF air emissions account methodology, which underpins the emission

DRAFT

data in ocean accounts, attributes emissions to the economic unit responsible for the direct release. This corresponds to Scope 1 emissions by definition. Ocean accounts based on the SEEA CF air emissions methodology directly capture Scope 1 emissions attributed by industry. Scope 2 emissions can be derived by reallocating electricity generation emissions to purchasing industries using supply-use data, whilst Scope 3 analysis requires supplementary supply chain modelling using input-output techniques as described in **TG-3.3** Section 3.4 on extended applications.

3.5 Climate Risk and Adaptation Indicators

¶1 Climate risk indicators assess the exposure and vulnerability of ocean systems and ocean-dependent economies to climate-related hazards; adaptation indicators track responses through ecosystem-based adaptation and conservation. This Circular addresses gradual, chronic climate risks (sea level rise, progressive acidification, long-term warming) whilst **TG-2.9 Disaster Risk Indicators** addresses acute event-based hazards. Where measurement approaches overlap — for example, coastal inundation mapping serving both gradual sea level rise assessment and acute storm surge modelling — compilers should ensure methodological consistency between the two indicator sets.

Physical risk indicators

¶1 Physical climate risks can be categorised following the IFRS S2 framework as either chronic (gradual, persistent changes) or acute (event-driven disruptions)[40]. This distinction affects both measurement methodology and disclosure requirements.

¶2 **Chronic physical risks:**

¶3 **Sea level rise exposure**: The area of coastal land, infrastructure, and ecosystems exposed to projected sea level rise under various scenarios:

- ¶4 Current elevation relative to mean sea level and high tide lines
- ¶5 Projected inundation under 0.5m, 1.0m, and 2.0m rise scenarios
- ¶6 Population and infrastructure within exposed zones

¶7 **Coastal erosion rates**: The rate of shoreline change, distinguishing between:

- ¶8 Erosion (negative change, land loss)
- ¶9 Accretion (positive change, land gain)
- ¶10 Attributable to sea level rise, storm intensity, or other climate factors

¶11 **Acute physical risks:**

¶12 **Marine heatwave exposure**: Frequency, intensity, and duration of marine heatwave events affecting the accounting area:

- ¶13 Number of marine heatwave days per year
- ¶14 Maximum intensity (degrees above climatological mean)
- ¶15 Ecosystem impact (coral bleaching, species displacement)

¶16 **Storm and cyclone exposure**: Frequency and intensity of extreme weather events affecting coastal and marine areas, with potential attribution to climate change. Indicators in this category should be compiled in coordination with the acute hazard indicators in **TG-2.9** to ensure consistent treatment of event definitions and thresholds.

Ecosystem vulnerability indicators

¶1 **Coral bleaching indices**: The frequency and severity of coral bleaching events, linked to sea surface temperature anomalies and marine heatwaves. Repeated bleaching compromises reef resilience and recovery capacity.

DRAFT

¶2 **Ecosystem condition change**: Changes in ecosystem condition indicators attributable to climate factors, as recorded in condition accounts:

- ¶3 Seagrass decline from thermal stress
- ¶4 Mangrove die-off from altered hydrology
- ¶5 Species range shifts from changing temperatures

¶6 **Climate-vulnerable ecosystem extent**: The area of ecosystems identified as highly vulnerable to climate impacts, based on sensitivity and adaptive capacity assessments.

Economic risk indicators

¶1 **Climate-exposed ocean economy**: The share of ocean economic activity (value added, employment) in sectors highly exposed to climate physical risks:

- ¶2 Coastal tourism dependent on beach and reef conditions
- ¶3 Fisheries dependent on climate-sensitive stocks
- ¶4 Aquaculture in areas subject to marine heatwaves or extreme events

¶5 **Projected production impacts**: Modelled changes in ecosystem service provision (fisheries yield, coastal protection, carbon sequestration) under climate scenarios.

Adaptation indicators

¶1 **Nature-based solution deployment**: Area of ecosystem-based adaptation implemented:

- ¶2 Mangrove restoration for coastal protection
- ¶3 Seagrass restoration for carbon sequestration
- ¶4 Coral reef restoration for biodiversity and tourism

¶5 The thematic guidance in **TG-6.2 Mangrove and Coastal Wetland Accounting** provides detailed methodology for accounting for these blue carbon ecosystems and their climate adaptation services.

¶6 **Coastal protection ecosystem services**: The value of natural coastal protection provided by coastal ecosystems, representing avoided damages from storm surge and flooding. This indicator links ecosystem condition to climate adaptation benefits.

¶7 **Climate adaptation expenditure**: Climate adaptation expenditure as an ocean account indicator is currently developmental, pending formal guidance on its classification within the SEEA CF environmental protection expenditure account (EPEA) framework. The CEPA 2000 classification, which structures the EPEA, does not include climate adaptation as a standalone class; adaptation expenditure must currently be imputed from CEPA class 1 (protection of ambient air and climate) and potentially other classes, with significant methodological ambiguity in separating adaptation from mitigation and from general coastal infrastructure investment. Compilers should consult SEEA CF Chapter 4 on the EPEA and the CEPA 2000 classification for current guidance. An ocean-specific spatial filter will be required to isolate marine and coastal adaptation expenditure when EPEA compilation guidance is finalised. [41]

¶8 **Resilience indicators**: Rather than a composite index — which requires aggregation methodology, weighting, and normalisation approaches not yet standardised for this domain — resilience to climate hazards should be reported as separately measurable indicator components:

- ¶9 **Area under ecosystem-based coastal protection** (hectares): The extent of mangrove, salt marsh, seagrass, and reef habitat providing quantified coastal protection services, compiled from extent accounts.
- ¶10 **Number of early warning systems operational**: A count of functioning coastal and marine early warning systems (for storm surge, tsunami, and marine heatwave), compiled from national disaster risk management registries.

DRAFT

- ¶11 **Ecosystem integrity index**: The composite condition index for coastal and marine ecosystems, compiled using the methodology in **TG-2.1 Aggregate Biophysical Indicators** Section 3.4.3.

¶12 These components can be reported individually and benchmarked against national targets or baseline periods without requiring aggregation. A weighted composite resilience index may be introduced in a future revision of this Circular when GGA indicator guidance provides a standardised aggregation framework. [42]

¶13 The Paris Agreement's Global Goal on Adaptation (GGA) framework is developing standardised metrics for assessing adaptation effectiveness at national and global scales [43]. As the GGA indicator framework is progressively elaborated, compilers should monitor developments and align adaptation indicators with the emerging international framework where practicable, whilst maintaining consistency with the accounting structures described in this Circular.

3.6 Worked Example: Ocean Sector GHG Emission Intensity

¶1 This worked example demonstrates the compilation procedure for a specific emission intensity indicator: GHG emissions per unit of gross value added for the marine fishing industry. All figures are illustrative and designed to show the accounting logic; actual compilations would use observed data from national air emissions accounts and ocean economy accounts.

Scenario: National marine fishing emissions intensity

¶1 **Context.** A coastal State compiles ocean accounts including air emissions accounts for ocean industries and ocean economy supply-use tables. The compiler seeks to derive the GHG emission intensity indicator for the marine fishing industry (ISIC 0311) for use in national climate reporting and to track progress toward sectoral emission reduction targets.

¶2 **Step 1: Extract emissions data.** From the air emissions account for the accounting period (Year N), the compiler identifies the row for ISIC 0311 (Marine fishing) and records the total GHG emissions:

Industry	Emissions (tonnes CO2e)
ISIC 0311 Marine fishing	450,000

DRAFT

¶3 The emissions figure represents Scope 1 direct emissions from vessel fuel combustion (diesel, gasoline) during fishing operations, recorded at the point of release from the vessel.

¶4 **Step 2: Extract activity data.** From the ocean economy supply-use table for Year N, the compiler extracts two activity measures:

Activity measure	Value	Unit
Landed catch	180,000	tonnes
Industry GVA	75,000,000	currency units

¶5 **Step 2a: Verify temporal alignment.** The compiler confirms that the air emissions account and the supply-use table both reference Year N. In this example, the air emissions account is published with a two-year lag; the most recently published account covers Year N-2. The compiler interpolates Year N emissions using a linear trend from Years N-4 to N-2 and records this interpolation in the indicator metadata, specifying the method and the resulting uncertainty contribution. The indicator is published with a metadata note disclosing that the emissions numerator is an interpolated estimate for Year N derived from the Year N-2 published account.

¶6 **Step 3: Calculate intensity ratios.** The compiler calculates two intensity indicators:

¶7 (a) **Emissions per tonne of landed catch:**

> *450,000 tonnes CO2e / 180,000 tonnes catch = **2.5 tonnes CO2e per tonne of catch***

¶8 (b) **Emissions per unit of GVA:**

> *450,000 tonnes CO2e / 75,000,000 currency units = 0.006 tonnes CO2e per currency unit = **6,000 kg CO2e per thousand currency units of GVA***

¶9 **Step 4: Disaggregate by gear type (optional).** Where data permit, the compiler disaggregates the intensity indicator by fishing method. Using supplementary data from the fisheries management authority on fleet composition and catch by gear type:

Gear type	Emissions (tonnes CO2e)	Catch (tonnes)	Intensity (kg CO2e/tonne)
Bottom trawl	180,000	45,000	4,000
Purse seine	120,000	90,000	1,333
Longline	90,000	30,000	3,000
Other	60,000	15,000	4,000
Total	**450,000**	**180,000**	**2,500**

¶10 This disaggregation reveals that purse seine fishing has substantially lower emission intensity (1,333 kg CO2e per tonne) compared to bottom trawl (4,000 kg CO2e per tonne), informing policy discussions on transitioning to lower-emission fishing methods.

¶11 **Step 5: Compile time series.** The compiler repeats the calculation for Years N-4 through N to construct a five-year time series:

Year	Emissions (tonnes CO2e)	Catch (tonnes)	Intensity (kg CO2e/tonne)
N-4	500,000	170,000	2,941
N-3	480,000	175,000	2,743
N-2	470,000	178,000	2,640
N-1	460,000	179,000	2,570
N	450,000	180,000	2,500

DRAFT

¶12 The time series demonstrates declining emission intensity over the five-year period (from 2,941 to 2,500 kg CO2e per tonne), a 15 per cent reduction. This indicates relative decoupling of emissions from fishing production, potentially driven by fleet modernisation, fuel efficiency improvements, or shifts in gear composition.

¶13 **Step 6: Document and report.** The compiler documents:

- ¶14 **Data sources**: Air emissions account (national statistics office), ocean economy accounts (marine agency), fleet composition (fisheries authority)
- ¶15 **Coverage**: Emissions data cover Scope 1 direct emissions only; Scope 2 and 3 are not included
- ¶16 **Exclusions**: Small-scale and subsistence fishing are excluded due to data limitations (estimated to represent 10 per cent of national catch)
- ¶17 **Coverage gap treatment**: The excluded 10 per cent of catch is a quantifiable subset. In accordance with UNFCCC Enhanced Transparency Framework (ETF) completeness requirements, compilers must either (a) apply a Tier 1 emission factor to the estimated excluded catch (total national catch = 180,000 / 0.9 = 200,000 tonnes; excluded catch = 200,000 × 0.1 = 20,000 tonnes) to produce a complete indicator, or (b) report the indicator as a partial estimate explic-

itly covering 90 per cent of national catch and flag this as an incompleteness in the national reporting tables. For NDC sectoral analysis — as used in this example — the UNFCCC ETF Modalities, Procedures, and Guidelines (Annex III) require estimation of excluded categories even at Tier 1; omitting them without estimation would constitute a material incompleteness. [44]

- ¶18 **Uncertainty**: Emissions data have an estimated uncertainty of plus or minus 8 per cent based on fuel consumption survey error
- ¶19 **Policy use**: Indicator feeds into NDC sectoral analysis. The emissions behind it are fuel combustion, which the national GHG inventory reports in the Energy sector (category 1.A.4.c.iii, fishing), not in AFOLU [45]

¶20 The indicator is published in the national climate reporting tables and the ocean accounts publication, with time series enabling trend analysis and assessment against national emission reduction targets.

Case illustration: Offshore renewable energy emission intensity (ISIC 3510)

¶1 The compilation of emission intensity for offshore renewable energy generation presents additional steps due to the need to disaggregate offshore wind and wave/tidal capacity from broader electricity generation data. The following illustration demonstrates the approach for offshore wind.

¶2 **Step A: Identify offshore wind capacity from licensing records.** The compiler obtains the national offshore wind licensing registry from the energy regulator. The registry lists each licensed offshore wind farm, its rated capacity (MW), commissioning date, and spatial coordinates. Active farms in the accounting year total 850 MW of installed capacity.

¶3 **Step B: Calculate capacity factor-adjusted generation.** Apply the national or technology-specific capacity factor (in this example, 38 per cent, consistent with regional offshore wind performance) to derive annual energy output:

> *850 MW × 8,760 hours × 0.38 capacity factor = 2,828 GWh = 10.18 PJ*

DRAFT

¶4 **Step C: Apply emission factor for direct operations.** Offshore wind farms produce minimal Scope 1 emissions during operation — primarily from maintenance vessels and facility backup generators. Apply an operations-phase emission factor (in this example, 2.5 kg CO2e per MWh from maintenance vessel fuel, sourced from plant operator reports):

> *2,828,000 MWh × 2.5 kg CO2e/MWh = 7,070 tonnes CO2e (Scope 1)*

¶5 **Step D: Calculate Scope 1 intensity.** Divide Scope 1 emissions by energy output:

> *7,070 tonnes CO2e / 2,828,000 MWh = 0.0025 tonnes CO2e/MWh =* ***2.5 kg CO2e/MWh***

¶6 **Step E: Report lifecycle intensity as supplementary metric.** Because direct operational emissions for offshore renewables are near-zero, the Scope 1 intensity indicator alone does not convey the full climate relevance of the sector. Compilers should additionally report the lifecycle (Scope 3) carbon intensity using published lifecycle assessment estimates for offshore wind (typically 7–15 g CO2e/kWh including manufacturing, installation, and decommissioning). This supplementary metric should be clearly labelled as a lifecycle estimate derived from external LCA literature, not from the ocean accounts air emissions account. [46]

¶7 **Step F: Handle non-disaggregable residual.** Where a share of ISIC 3510 production cannot be attributed to offshore renewables through licensing records (e.g., unlicensed small installations,

shared grid connections), the compiler should document the unattributable share and report the offshore renewable intensity as covering the licensed portion only (ISIC classification: Table 2, footnote [36]).

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

5. References

1. ¶1 United Nations et al., *System of Environmental-Economic Accounting – Ecosystem Accounting* (New York: United Nations, 2021).
2. ¶2 United Nations et al., *System of Environmental-Economic Accounting 2012 – Central Framework* (New York: United Nations, 2014).
3. ¶3 United Nations, *Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development*, A/RES/71/313.
4. ¶4 United Nations (2015). *Paris Agreement*. Adopted under the United Nations Framework Convention on Climate Change. Article 4 on nationally determined contributions and Article 7 on adaptation.
5. ¶5 Kunming-Montreal Global Biodiversity Framework (2022). Decision 15/4 of the Conference of the Parties to the Convention on Biological Diversity. Target 8 on minimising the impact of climate change and ocean acidification on biodiversity.
6. ¶6 IFRS Foundation, *IFRS S2 Climate-related Disclosures* (London: IFRS Foundation, 2023).
7. ¶7 IPCC, *Special Report on the Ocean and Cryosphere in a Changing Climate* (Cambridge: Cambridge University Press, 2019), Chapter 5.
8. ¶8 See SEEA EA, Chapter 13, for guidance on thematic accounts including carbon stock accounts that provide the foundation for ocean-climate indicator compilation.
9. ¶9 IFRS S2, paragraphs 29-32, specifies requirements for greenhouse gas emissions disclosure including Scope 1, 2, and 3 emissions and cross-industry metrics.
0. ¶10 SDG indicator 14.3.1: Average marine acidity (pH) measured at agreed suite of representative sampling stations.
1. ¶11 IPCC, *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands* (Geneva: IPCC, 2014).
2. ¶12 As of 2024, over 70 countries reference ocean-based climate actions in their NDCs, spanning blue carbon conservation, sustainable fisheries, marine renewable energy, and coastal adaptation measures. See UNFCCC NDC Registry for current submissions.
3. ¶13 Taskforce on Nature-related Financial Disclosures, *Recommendations of the Taskforce on Nature-related Financial Disclosures* (September 2023).
4. ¶14 Nellemann, C. et al. (eds.), *Blue Carbon: The Role of Healthy Oceans in Binding Carbon* (UNEP, FAO, UNESCO-IOC, IUCN, 2009).
5. ¶15 Mcleod, E. et al., "A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO2", *Frontiers in Ecology and the Environment* 9, no. 10 (2011): 552-560.
6. ¶16 SEEA EA, paragraphs 6.110-6.113, describe the accounting treatment of global climate regulation services including carbon sequestration and carbon retention.
7. ¶17 Values represent indicative ranges compiled from multiple studies; local rates vary substantially with ecosystem condition and environmental factors.
8. ¶18 IPCC (2014). *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands*, Chapter 4, Table 4.2. Default sequestration rates are derived from long-term sediment carbon accumulation studies and approximate NECB rather than gross primary production. See also Howard, J. et al. (2014). *Coastal Blue Carbon: Methods for Assessing Carbon Stocks and Emissions Factors*. IUCN, Conservation International, IOC-UNESCO, Appendix B.
9. ¶19 United Nations Convention on the Law of the Sea (UNCLOS), Part V, Articles 55–75, on the Exclusive Economic Zone. Articles 56–57 establish coastal State sovereign rights for exploring, exploiting, conserving, and managing natural resources within the EEZ.
0. ¶20 SEEA EA, Table 13.3, presents the structure of carbon stock accounts disaggregating stocks by carbon pool type.
1. ¶21 Carbon stock estimates are indicative and include both biomass and sediment carbon pools. Sediment carbon stocks depend on sediment depth, which can extend metres below the surface in mature coastal ecosystems.
2. ¶22 IPCC (2014). *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands*. Chapter 4 provides Tier 1 emission factors for coastal wetland conversion, disaggregated by carbon pool and disturbance type.
3. ¶23 SEEA EA, paragraphs 6.110-6.113 on the measurement of carbon retention services; see also Chapter 8 on monetary valuation approaches for ecosystem services.

DRAFT

4. ¶24 The annuity approach to carbon service valuation is described in SEEA EA annex A12.1 and in the SEEA Valuation technical guidance.
5. ¶25 High-Level Commission on Carbon Prices (2017). *Report of the High-Level Commission on Carbon Prices*. World Bank, Washington, DC. The Commission recommended carbon prices of USD 40–80 per tonne CO2 by 2020 and USD 50–100 by 2030 to achieve Paris Agreement goals.
6. ¶26 Bunting, P. et al. (2018). "The Global Mangrove Watch – A New 2010 Global Baseline of Mangrove Extent", *Remote Sensing* 10, no. 10: 1669. The Global Mangrove Watch provides standardised annual mangrove extent maps from 1996 to present.
7. ¶27 IPCC, *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands* (Geneva: IPCC, 2014), Chapters 2–4. Note: the 2006 Guidelines Volume 4 Chapter 4 covers Forest Land; coastal wetland methodologies are in the 2013 Wetlands Supplement.
8. ¶28 Doney, S.C. et al., "Ocean Acidification: The Other CO2 Problem", *Annual Review of Marine Science* 1 (2009): 169–192.
9. ¶29 SDG 14.3.1 methodology notes that measurements should be taken at representative stations covering coastal and open ocean areas within national jurisdiction.
0. ¶30 The aragonite saturation state (omega-a) is calculated from dissolved inorganic carbon, total alkalinity, temperature, salinity, and pressure.
1. ¶31 Newton, J.A. et al. (2015). *Global Ocean Acidification Observing Network: Requirements and Governance Plan*. Second Edition. GOA-ON. The GOA-ON maintains a data portal, quality standards, and best practices for acidification observations.
2. ¶32 IOC-UNESCO, SDG 14.3.1 indicator metadata and methodology (maintained by the IOC-UNESCO custodian agency); Shutler, J.D. et al. (2020). "Satellites will address critical science priorities for the ocean decade." *Frontiers in Earth Science* 8: 320; GOA-ON best practices documentation for satellite pH products.
3. ¶33 World Resources Institute and World Business Council for Sustainable Development (2004). *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*. Revised Edition.
4. ¶34 United Nations et al. (2025). *System of National Accounts 2025*. Chapter 35 addresses environmental-economic accounting including residual flows from economic activity to the environment.
5. ¶35 SEEA CF, para 3.173, on reference period consistency in environmental accounts; Eurostat, *Air Emissions Accounts: Compilation Guide* (2019), Section 4.2 on temporal alignment of emissions and activity data.
6. ¶36 In ISIC Rev.4, class 3510 covers all electric power generation, transmission, and distribution. ISIC Rev.4 does not distinguish generation technology type at the 4-digit class level; the subdivision into renewable and non-renewable generation was introduced in ISIC Rev.5 (endorsed 2024). National compilers using European classifications should note that NACE Rev.2 code 35.11 (which does distinguish technology type) is an adaptation of ISIC Rev.4, not an ISIC code. Until ISIC Rev.5 is adopted, identification of the offshore renewable subset requires supplementary data from energy statistics, licensing registries, or national energy balances.
7. ¶37 IMO, *Fourth IMO Greenhouse Gas Study 2020* (London: International Maritime Organization, 2021).
8. ¶38 SDG indicator 9.4.1: CO2 emission per unit of value added, calculated as the ratio of total CO2 emissions from fuel combustion to total industry value added.
9. ¶39 The GHG Protocol Corporate Standard and IFRS S2 define the scope categories, with detailed guidance for Scope 3 emissions in the GHG Protocol Scope 3 Standard.
0. ¶40 IFRS S2, Appendix A, distinguishes physical risks as either "acute" (event-driven, such as cyclones and floods) or "chronic" (longer-term shifts, such as sea level rise and sustained higher temperatures). This classification follows the TCFD framework.
1. ¶41 SEEA CF, Chapter 4 (Environmental Protection Expenditure Accounts); CEPA 2000 classification of environmental protection activities. OECD DAC climate marker methodology provides an approach to adaptation expenditure tagging in development finance contexts but is not directly applicable to national accounts.
2. ¶42 TG-2.1, Section 3.3, describes the composite condition index methodology including normalisation and aggregation; SEEA EA, Chapter 7, on ecosystem condition accounts; UNFCCC GGA Glasgow-Sharm el-Sheikh work programme on adaptation indicators.
3. ¶43 The Glasgow-Sharm el-Sheikh work programme on the Global Goal on Adaptation (GGA) was established at COP26 and elaborated at COP27-COP28. The framework aims to enhance adaptive capacity, strengthen resilience, and reduce vulnerability to climate change, with indicators under progressive development.
4. ¶44 UNFCCC, *Modalities, Procedures, and Guidelines for the Transparency Framework for Action and Support* (MPGs), Decision 18/CMA.1, Annex III, paragraph 16, on completeness requirements for GHG inventories under the Enhanced Transparency Framework. IPCC (2006). *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 1, Chapter 1, Section 1.3, on completeness as an inventory quality criterion.
5. ¶45 IPCC, *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 2: Energy, Chapter 3 (Mobile Combustion), Section 3.5 (Water-borne Navigation), which covers fishing (1.A.4.c.iii).
6. ¶46 ISIC Rev.4 class 3510 notes; IEA offshore wind statistics methodology; lifecycle emission intensity estimates for offshore wind are typically in the range of 7–15 g CO2e/kWh based on published LCA literature; IRENA (2021). *Renewable Power Generation Costs in 2020*, Annex.

DRAFT

DRAFT

Multilateral Environmental Agreement Indicators

Provides guidance on deriving multilateral environmental agreement (MEA) indicators from ocean accounts.

Version 0.7.3 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

OUTCOME

This Circular provides guidance on deriving multilateral environmental agreement (MEA) indicators from ocean accounts, enabling countries to report against international commitments through a unified data infrastructure. Readers will understand how ocean accounts support indicator compilation for Sustainable Development Goal 14 (Life Below Water), the Kunming-Montreal Global Biodiversity Framework (GBF), the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC), and the Agreement on Biodiversity Beyond National Jurisdiction (BBNJ).

Decision-makers will be equipped to use ocean accounts for tracking progress against GBF Target 3 (30x30 protection), SDG 14 targets on marine pollution and fish stocks, Paris Agreement nationally determined contributions (NDCs) for blue carbon and ocean-climate linkages, and emerging BBNJ requirements for areas beyond national jurisdiction.

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 3
3.1 MEA Indicator Framework 4
3.2 SDG 14 Indicators (Life Below Water) 6
3.3 CBD/GBF Indicators (Targets 2, 3, 15) 8
3.4 UNFCCC/Paris Agreement Indicators (NDCs) 10
3.5 BBNJ Agreement Indicators (Emerging horizon scanning) 11
3.6 Compilation Procedure: Worked Example 13
3.7 MEA-Account Alignment 18
4. Acknowledgements 19
5. References 19

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Multilateral Environmental Agreement Indicators (2026) (GOAP Technical Guidance on Ocean Accounting, TG-2.10, v0.7.3). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-2/2-10-mea-indicators/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

1. Outcome

¶1 This Circular provides guidance on deriving multilateral environmental agreement (MEA) indicators from ocean accounts, enabling countries to report against international commitments through a unified data infrastructure. Readers will understand how ocean accounts support indicator compilation for Sustainable Development Goal 14 (Life Below Water), the Kunming-Montreal Global Biodiversity Framework (GBF), the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC), and the Agreement on Biodiversity Beyond National Jurisdiction (BBNJ).

¶2 Decision-makers will be equipped to use ocean accounts for tracking progress against GBF Target 3 (30x30 protection), SDG 14 targets on marine pollution and fish stocks, Paris Agreement nationally determined contributions (NDCs) for blue carbon and ocean-climate linkages, and emerging BBNJ requirements for areas beyond national jurisdiction.

2. Requirements

¶1 This Circular requires familiarity with:

- ¶2 **TG-0.1 General Introduction to Ocean Accounts** – for the conceptual framework and key components of Ocean Accounts
- ¶3 **TG-0.2 Overview of Relevant Statistical Standards** – for the methodological foundations provided by SNA 2025, SEEA CF, and SEEA EA
- ¶4 **TG-2.1 Aggregate Biophysical Indicators** – for the biophysical indicator derivation framework referenced throughout this Circular

¶5 Related Circulars that provide supporting guidance:

- ¶6 **TG-2.5 Ocean Economy Structure** – for ocean economy measurement relevant to SDG 14.7.1
- ¶7 **TG-2.7 Pollution Flows** – for pollution flow accounting relevant to SDG 14.1.1
- ¶8 **TG-2.8 Climate Indicators** – for climate-related indicators relevant to UNFCCC/Paris Agreement
- ¶9 **TG-2.9 Disaster Risk and Resilience** – for ecosystem-based adaptation indicators
- ¶10 **TG-3.1 Asset Accounts** – for guidance on compiling physical and monetary asset accounts for marine ecosystems
- ¶11 **TG-3.1 Asset Accounts** Section 3.4.2 – for ecosystem condition accounting methodology that underpins GBF and SDG indicators
- ¶12 **TG-3.7 Governance Accounts** – for information on marine protected areas and governance arrangements relevant to MEA reporting
- ¶13 **TG-3.8 Combined Presentations** – for practical methods of integrating data from multiple accounts to derive MEA indicators

3. Guidance Material

¶1 The ocean domain is addressed by multiple overlapping MEAs. The overlap risks fragmented and duplicative reporting where each agreement is served by a separate data exercise, but it also allows a single account to satisfy several reporting obligations at once. SEEA Ecosystem Accounting (SEEA EA) was adopted by the United Nations Statistical Commission in March 2021 as the international statistical standard for ecosystem accounting. The preface explicitly recognises that the framework will "inform international initiatives and global reporting frameworks, including the Sustainable Development Goals, the Kunming-Montreal Global Biodiversity Framework…and the

DRAFT

measurement of GHG emissions and removals by land use, land-use change and forestry (LULUCF) under the United Nations Framework Convention on Climate Change"[1].

¶2 This section examines how ocean accounts can support indicator derivation for the major MEAs relevant to marine ecosystems. Section 3.1 provides an overview of the MEA indicator framework and SEEA's role. Sections 3.2 through 3.5 address specific agreements: SDG 14, CBD/GBF, UNFCCC/Paris Agreement, and the BBNJ Agreement. Section 3.6 presents an expanded worked example demonstrating the compilation procedure for deriving MEA indicators from ocean account data. Section 3.7 provides a reporting frequency harmonisation note.

3.1 MEA Indicator Framework

¶1 Indicators are essential tools for monitoring progress toward environmental goals. The SEEA EA describes indicators as "summary measures related to a key issue or phenomenon and derived from a series of observed facts"[2]. Indicators derived from accounting frameworks benefit from the coherence and consistency that accounts provide, as the underlying data have been reconciled and harmonised across multiple sources. Figure 2.10.1 illustrates how a single SEEA-based ocean account, compiled once, can serve multiple multilateral instruments simultaneously.

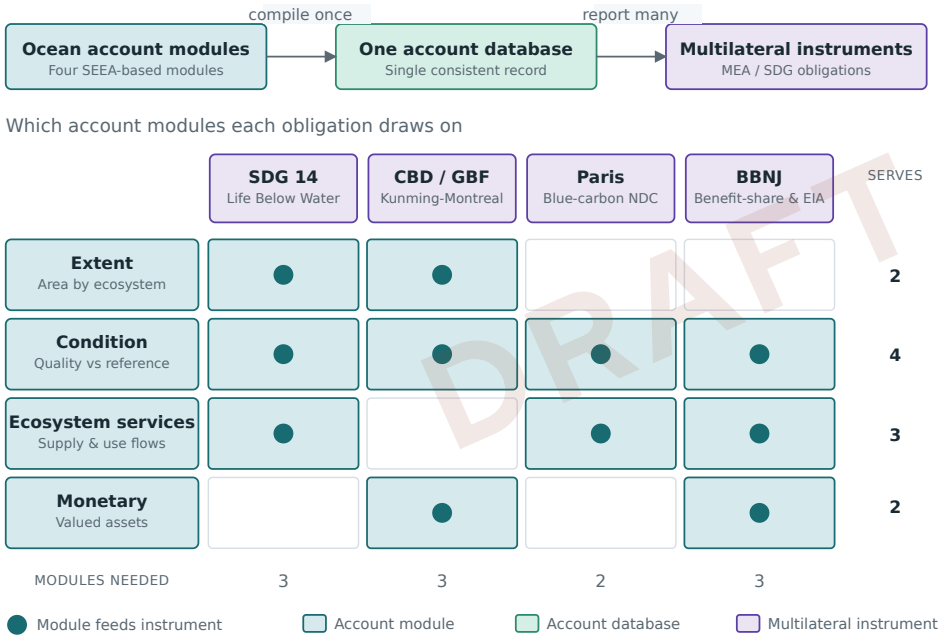


Figure 2.10.1 One SEEA-based ocean account compilation feeds multiple multilateral reporting obligations through a module-by-instrument matrix. Filled cells mark modules that feed an instrument; Condition supports all four instruments shown.

Source: TG-2.10 draft §3.1 (MEA reporting matrix) and §3.5 (BBNJ condition- and service-based environmental impact assessment); SEEA EA §3.30–3.54 (extent), §3.55–3.78 (condition).

The role of accounting in indicator derivation

¶1 Chapter 14 of SEEA EA identifies three main types of indicators that can be derived from ecosystem accounts, as summarised in Table 3.1.1 below.[3]

Type	Description
Aggregates	Statistics grouped together to provide a broader picture, such as total marine protected area coverage or total ecosystem service value.
Composite indices	Indicators combining different variables using weighting patterns, such as ecosystem condition indices aggregated from multiple condition variables.
Ratio indicators	Indicators derived by combining data from different accounts, such as ecosystem services per hectare by ecosystem type.

¶2 The SEEA EA notes that indicators derived from accounting frameworks offer several advantages[4]:

- ¶3 A stable conceptual framework allowing new indicators to be developed as policy demands evolve
- ¶4 A broad framework enabling different indicators to be understood in context
- ¶5 Support for analysis, forecasting, and projections using the same coherent data source
- ¶6 Capacity for early estimates based on benchmark data

¶7 The combined presentations approach described in **TG-3.8 Combined Presentations** provides practical methods for integrating data from multiple accounts to derive MEA indicators.

SEEA and global monitoring frameworks

¶1 The UN Statistical Commission has recognised the importance of SEEA for monitoring the Sustainable Development Goals, welcoming the work on interlinkages between SEEA and SDG indicators[5]. Similarly, the monitoring framework for the Kunming-Montreal Global Biodiversity Framework draws directly on SEEA EA for several headline indicators, including those under Goals A and B[6].

¶2 The SEEA EA provides two general advantages for MEA monitoring[7]:

1. ¶3 **Broad coverage** of environmental and economic topics, with inherent connections between stocks and flows and use of both physical and monetary data
2. ¶4 **Single coherent database** enabling countries to report to multiple monitoring frameworks from a unified data infrastructure[8]

DRAFT

Decision use cases for MEA indicators

¶1 Ocean account-derived MEA indicators support specific policy and management decisions across multiple governance levels:

¶2 **National policy planning:** Governments use MEA indicators to assess progress toward international commitments and to identify priority areas for policy intervention. SDG 14.5.1 (marine protected area coverage) informs national spatial planning decisions, whilst SDG 14.4.1 (fish stocks within sustainable levels) guides fisheries policy reform. The integrated nature of ocean accounts enables assessment of trade-offs between conservation and sustainable use objectives, supporting evidence-based policy design.

¶3 **International reporting:** Multilateral environmental agreements require periodic national reports demonstrating implementation progress. Ocean accounts provide the data foundation for GBF National Reports, Voluntary National Reviews on SDG progress, and UNFCCC National Communications and Biennial Reports. By deriving multiple indicators from a single accounting framework, countries ensure consistency across reporting obligations and reduce the administrative burden of fragmented reporting systems.

¶4 **Sub-national management:** Regional and local authorities responsible for marine spatial management use MEA indicators to track ecosystem condition and management effectiveness within their jurisdictions. Protected area managers assess condition indicators to evaluate whether con-

servation measures are achieving desired outcomes, whilst coastal development authorities use pollution indicators to monitor land-sea interactions.

¶5 **Private sector disclosure:** The Taskforce on Nature-related Financial Disclosures (TNFD) framework, aligned with GBF Target 15, encourages businesses to assess and disclose nature-related dependencies, impacts, risks and opportunities. Ocean accounts provide standardised metrics that companies operating in marine sectors can use for TNFD-aligned disclosure, connecting corporate sustainability reporting with national environmental accounting [9]. Practical application at project or operational scale requires spatial disaggregation of national-scale account data. Section 3.3 (Target 15) discusses the scale mismatch further.

¶6 **Investment screening (medium-term aspiration):** Development finance institutions and private investors increasingly use environmental indicators for investment screening and portfolio risk assessment. MEA indicators derived from ocean accounts can in principle provide decision-useful information on ecosystem condition trends, regulatory risks associated with environmental degradation, and opportunities in nature-positive sectors such as sustainable aquaculture and marine renewable energy. Operationalising this use case is, however, contingent on the development of open data infrastructure that connects NSO-published accounts to DFI and investor workflows. This requires dissemination in machine-readable formats (e.g., SDMX for environmental statistics, open government data portals) and alignment with emerging market data exchange standards such as those being developed by TNFD. The GOAP data standards initiative provides the appropriate forum for advancing this infrastructure. Until it matures, the investment screening use case should be treated as a medium-term aspiration rather than an operational service from current national ocean accounts.

3.2 SDG 14 Indicators (Life Below Water)

¶1 Sustainable Development Goal 14 aims to "Conserve and sustainably use the oceans, seas and marine resources for sustainable development" [10]. It comprises ten targets addressing marine pollution, ecosystem management, ocean acidification, fisheries, marine protected areas, fisheries subsidies, economic benefits for SIDS and LDCs, marine research, small-scale fisheries, and implementation of international ocean law, each with its own official indicators [11].

DRAFT

Overview of SDG 14 targets and indicators

Target	Focus area
14.1	Coastal eutrophication and marine pollution
14.2	Ecosystem-based management of marine areas
14.3	Ocean acidification
14.4	Sustainable fish stocks
14.5	Marine protected areas
14.6	Illegal, unreported and unregulated fishing
14.7	Sustainable fisheries as proportion of GDP
14.a	Marine technology research investment
14.b	Small-scale fisheries access rights
14.c	Ocean-related international law implementation

¶1 *Table 1: SDG 14 targets overview [12]. Per-indicator compilation guidance is provided in Section 3.2.*

Ocean accounts contribution to SDG 14 indicators

¶1 A general note applies throughout this subsection: for indicators with designated UN custodian agencies, the official indicator value submitted to the global SDG database must be compiled in

accordance with the custodian methodology. Ocean account-derived values that do not match the custodian formula should be positioned as supplementary national indicators or as inputs to the official compilation process, not as substitutes for the custodian-aligned submission.

¶2 **Indicator 14.1.1 (Coastal eutrophication and plastic debris):** Physical flow accounts for residuals (pollutants) can record nutrient loadings and plastic debris entering marine ecosystems from land-based sources. The SEEA Central Framework physical flow accounts provide the methodology for tracking pollutant flows from economic activities to the environment[13]. For guidance on pollution flow accounting, see **TG-2.7 Pollution Flows**.

¶3 The indicator comprises two components that can be derived from distinct accounting sources. The coastal eutrophication index (CEI) aggregates information on nutrient concentrations (dissolved inorganic nitrogen and phosphorus) and harmful algal bloom occurrences from condition accounts, combined with nutrient loading data from physical flow accounts. The plastic debris density component uses data on plastic accumulation rates from residual flow accounts and marine litter surveys compiled within the condition accounting framework. Both components require spatial disaggregation to the coastal zone, achievable through the spatial classification systems described in **TG-0.1 General Introduction**.

¶4 **Indicator 14.2.1 (Ecosystem-based approaches):** SDG 14.2.1 ("Number of countries using ecosystem-based approaches to managing marine areas") is a Tier II policy survey indicator compiled by UNEP, its custodian, through a national survey instrument that asks countries whether they have adopted ecosystem-based approaches to managing marine areas[14]. The indicator value itself is the country's response to that survey — it is not directly derived from quantitative ecological data. Ocean accounts cannot substitute for the survey response, but ecosystem extent and condition accounts, combined with governance accounts recording marine protected area coverage and management effectiveness, provide supporting evidence that countries can cite when completing the UNEP questionnaire. Relevant account outputs to reference include: documentation of MPA designation and management (governance accounts), condition monitoring programmes within and outside MPAs (condition accounts), and institutional arrangements for marine spatial management[15]. For detailed guidance on governance arrangements in ocean accounts, see **TG-3.7 Governance Accounts**.

¶5 **Indicator 14.3.1 (Ocean acidification):** Ecosystem condition accounts include chemical state variables such as pH, dissolved oxygen, and carbonate chemistry[16]. Systematic recording of these variables within the condition accounting framework supports trend monitoring for ocean acidification. The official SDG 14.3.1 methodology (Tier II, IOC-UNESCO as custodian) requires data from an agreed suite of representative sampling stations following GOA-ON guidance, and ocean account-derived pH series should be compiled to be consistent with that methodology. For guidance on deriving biophysical indicators from condition accounts, see **TG-2.1 Aggregate Biophysical Indicators**. Climate-related applications of ocean acidification indicators are addressed in **TG-2.8 Climate Indicators** Section 3.3.

¶6 **Indicator 14.4.1 (Fish stocks within sustainable levels):** SDG 14.4.1 is a Tier I indicator for which FAO is the designated custodian. The official methodology classifies stocks into categories (underfished, maximally sustainably fished, overfished) using national stock assessment reports, not a direct biomass-to-BMSY ratio extracted from asset accounts[17]. SEEA CF physical asset accounts for aquatic resources record fish stock biomass, natural growth, harvest, and depletion[18], and these account data provide the physical stock input that feeds national stock assessment models. The BMSY reference points required for stock status classification are produced by those separate stock assessment modelling steps and are not, in themselves, asset account outputs (see general note above on custodian alignment). For detailed guidance on asset accounts including fish stocks, see **TG-3.1 Asset Accounts**.

¶7 **Indicator 14.5.1 (Marine protected area coverage):** Ecosystem extent accounts classified by protection status can directly provide this indicator. The SEEA EA supports disaggregation of eco-

DRAFT

system extent accounts by a range of spatial classifications, including protected area status [19]. This indicator connects directly to GBF Target 3 (30x30). A single unified accounting approach can therefore serve both reporting obligations.

¶8 **Indicator 14.7.1 (Sustainable fisheries as proportion of GDP):** SDG 14.7.1 is a Tier I indicator for which FAO is the designated custodian. The official custodian methodology uses a composite measure built from sustainability-weighted catch data and value-added information rather than a simple ratio of fisheries value added to GDP extracted from supply-use tables [20]. Monetary flow accounts linking ecosystem services to economic output, combined with supply-use tables for the ocean economy, can provide an important input to the official compilation, but a value derived only from supply-use tables falls under the general note above on custodian alignment [21]. The supply-use methodology in **TG-2.5 Ocean Economy Structure** provides an input to, not a replacement for, the official indicator.

3.3 CBD/GBF Indicators (Targets 2, 3, 15)

¶1 The Kunming-Montreal Global Biodiversity Framework (GBF), adopted in December 2022 at the fifteenth Conference of the Parties to the Convention on Biological Diversity (COP-15), sets out ambitious goals and targets for halting and reversing biodiversity loss by 2030 [22]. The monitoring framework for the GBF, adopted at COP-15 through Decision 15/5, comprises headline indicators, component indicators, and complementary indicators. SEEA is explicitly recognised as the methodological basis for several headline indicators.

¶2 GBF Goals A and B are particularly relevant to ocean accounting: Goal A monitors ecosystem integrity and extent (informed by ecosystem extent and condition accounts), and Goal B monitors nature's contributions to people (informed by ecosystem services flow accounts) [23]. GBF-aligned biophysical indicators for ocean ecosystems are defined and compiled following **TG-2.1 Aggregate Biophysical Indicators**.

Target 2: Ecosystem restoration

¶1 Target 2 aims to "Ensure that by 2030 at least 30 per cent of areas of degraded terrestrial, inland water, and marine and coastal ecosystems are under effective restoration" [24].

Account Type	Contribution
Ecosystem extent accounts	Recording changes in marine ecosystem extent, including restoration of degraded areas.
Ecosystem condition accounts	Tracking improvements in ecosystem condition following restoration interventions.
Combined presentations	Linking restoration expenditure (from environmental protection expenditure accounts) to outcomes in extent and condition.

¶2 The SEEA EA states that "Target 2, which monitors the area of degraded ecosystems under ecosystem restoration, can be informed by indicators deriving from a combination of ecosystem extent accounts and ecosystem condition accounts" [25].

¶3 A practical difficulty for compilers is determining which ecosystem units count as "degraded": the denominator of the Target 2 headline indicator. The GBF monitoring framework does not specify a single global threshold, and different national choices will produce non-comparable figures. The SEEA Ecosystem Condition Typology (ECT) classes can be used to operationalise this decision. Table 2A gives indicative degradation classifications and ECT class mappings.

¶4 *Table 2A: Indicative degradation classification using condition index thresholds*

DRAFT

Aggregate condition index (relative to reference)	Degradation class	Target 2 treatment	ECT class mapping (illustrative)
>= 0.85	Reference / near-reference	Not degraded; excluded from denominator	ECT Classes A1-A2 (abiotic physical and chemical state near reference)
0.60 to 0.85	Moderately altered	Optional inclusion; document rationale	ECT Class B1 (biotic compositional state altered)
0.40 to 0.60	Degraded	Included in degraded denominator	ECT Class B3 (functional state impaired)
< 0.40	Severely degraded	Included in degraded denominator; high restoration priority	ECT Class B3 combined with B2 structural state loss

¶5 The threshold values shown are illustrative. The GBF monitoring framework is still developing methodological guidance for Target 2, and compilers should flag the chosen thresholds, reference condition basis, and ECT mapping as an explicit assumption in compilation metadata. See **TG-3.1 Asset Accounts** Section 3.4.2 for guidance on ecosystem condition accounting methodology and ECT class definitions.

Target 3: Protected areas (30x30)

¶1 Target 3 aims to "Ensure and enable that by 2030 at least 30 per cent of terrestrial and inland water areas, and of marine and coastal areas...are effectively conserved and managed" [26].

Account Type	Contribution
Ecosystem extent accounts	Classified by protection status, distinguishing marine protected areas (MPAs), other effective area-based conservation measures (OECMs), and unprotected areas.
Ecosystem condition accounts	Comparing condition within and outside protected areas to assess conservation effectiveness.
Governance accounts	Recording management effectiveness evaluations and enforcement capacity.

DRAFT

¶2 For guidance on recording marine protected areas within the ocean accounting framework, see **TG-3.7 Governance Accounts**. Marine spatial planning processes that allocate ocean space for conservation and sustainable use are addressed in **TG-1.3 Marine Spatial Management**.

Target 15: Business disclosure

¶1 Target 15 calls for action to "Encourage and enable business...to regularly monitor, assess, and transparently disclose their risks, dependencies and impacts on biodiversity" [27].

¶2 The Taskforce on Nature-related Financial Disclosures (TNFD) has developed a framework aligned with Target 15 requirements [28]. The TNFD v1.0 recommendations, released in September 2023, draw on SEEA as a methodological foundation for nature-related metrics, with supplementary sector guidance (including for fishing and marine sectors) published as additional materials through 2024-2025 [29]. Ocean accounts can support corporate disclosure by:

- ¶3 Providing standardised metrics for ecosystem extent and condition that can be applied at project, operational, or portfolio scales (subject to the scale considerations discussed below)
- ¶4 Enabling consistent measurement of nature dependencies (ecosystem services used) and impacts (pressures on ecosystems) [30]
- ¶5 Supporting alignment between corporate reporting and national accounting

¶6 **Scale mismatch between national accounts and TNFD corporate disclosure.** National ocean accounts are typically compiled at ecosystem-type and EEZ/national resolution, whereas TNFD corporate disclosure requires location-specific, asset-level assessment of dependencies and

impacts. The two scales are not directly interchangeable. Bridging them requires a spatial disaggregation (or "downscaling") workflow in which:

- ¶7 national account values for ecosystem extent and condition by ecosystem type are intersected with the company's operational asset footprint;
- ¶8 site-level ecosystem data (often supplied by the company) are reconciled against the corresponding national ecosystem-type baselines so that corporate disclosure is consistent with national accounts; and
- ¶9 account-derived condition references provide the comparator against which site-level impacts are interpreted.

¶10 The SEEA EA guidance on sub-national accounts (Chapter 4, Section 4.4) provides the methodological basis for this disaggregation. Detailed operational guidance for company-side TNFD compilation is beyond the scope of this Circular and is better addressed in a dedicated applied circular on corporate disclosure. The role of TG-2.10 is to clarify that national ocean accounts do not, on their own, deliver project-scale TNFD outputs.

3.4 UNFCCC/Paris Agreement Indicators (NDCs)

¶1 The Paris Agreement, adopted in 2015, aims to limit global temperature increase to well below 2 degrees Celsius, with efforts to limit to 1.5 degrees Celsius [31]. Countries submit Nationally Determined Contributions (NDCs) outlining their climate commitments, which increasingly include ocean-based mitigation and adaptation measures.

Ocean-climate linkages in NDCs

¶1 Ocean ecosystems contribute to climate regulation through:

- ¶2 Carbon sequestration by coastal and marine ecosystems (blue carbon)
- ¶3 Heat absorption moderating global temperatures
- ¶4 Providing adaptation options for coastal communities

¶5 The SEEA EA recognises global climate regulation as an ecosystem service, defined as "the regulation of the chemical composition of the atmosphere and oceans by living organisms and ecosystem processes" [32]. Coastal ecosystems including mangroves, salt marshes, and seagrass meadows are particularly effective at carbon sequestration and storage. These ecosystems are covered in detail in **TG-6.2 Mangrove and Coastal Wetland Accounting** and **TG-6.3 Seagrass Accounts**.

Ocean accounts for climate indicators

¶1 Ocean accounts can support UNFCCC/Paris Agreement monitoring through:

¶2 **Blue carbon accounting:** Ecosystem extent accounts for mangroves, salt marshes, and seagrass meadows record the area of these carbon-rich ecosystems. Ecosystem condition accounts can include carbon stock variables (above-ground biomass, soil carbon). Ecosystem services flow accounts can record annual carbon sequestration rates [33], [34]. For guidance on climate-related indicators from ocean accounts, see **TG-2.8 Climate Indicators**.

¶3 **LULUCF reporting alignment:** Ecosystem extent accounts recording conversions between ecosystem types can be aligned with LULUCF activity data requirements [35]. This is particularly relevant for coastal wetland conversions (mangrove deforestation, wetland drainage), which are major sources of emissions.

¶4 The IPCC 2013 Wetlands Supplement requires activity data structured by specific coastal wetland categories with sub-classifications by land-use change type (conversions to and from each wetland category, plus rewetting and drainage). SEEA ecosystem extent accounts are typically classified using the IUCN Global Ecosystem Typology (GET), which does not map one-to-one to the IPCC categories. To produce GHG inventory-ready data from SEEA extent accounts, compilers

DRAFT

need a crosswalk that identifies (a) which SEEA/IUCN-GET ecosystem types correspond to each IPCC coastal wetland category and (b) where additional conversion factors, splits, or expert judgment are required.

¶5 *Table 2B: Indicative crosswalk — IUCN GET coastal wetland types to IPCC Wetlands Supplement activity data categories*

IUCN GET ecosystem functional group	IPCC Wetlands Supplement category	SEEA extent data sufficient?	Notes / conversion factors required
MFT1.2 Intertidal forests and shrublands (mangroves)	Mangroves	Yes (extent + change)	Direct mapping; activity data = SEEA extent transitions to/from mangrove class. Emission factors from IPCC Tier 1 unless national values available.
MFT1.3 Coastal saltmarshes and reedbeds	Tidal marshes	Yes (extent + change)	Direct mapping; SEEA extent transitions populate activity data. National emission factors preferred where soil carbon data exist.
M1.1 Seagrass meadows	Seagrass meadows	Yes (extent + change)	Direct mapping; sub-classification by canopy density may require additional condition data.
MT2.1 Coastal saltflats / supratidal saltmarshes	Other coastal wetlands (saltflats)	Partial	Requires split between vegetated and unvegetated portions; expert judgment or additional remote-sensing input needed.
F2.2 Constructed lacustrine wetlands; F3.1 Large reservoirs (coastal)	Constructed / managed coastal wetlands	Partial	Coastal-versus-inland boundary needs explicit definition; conversion factor required for the coastal share.
Drained / converted former wetland (recorded in SEEA as transition to artificial cover)	Drained organic soils — coastal wetlands	Conditional	SEEA records the extent transition; emission factor for drained organic soils must be applied separately. Time-since-drainage tracking required for Tier 2/3 estimation.

DRAFT

¶6 This crosswalk is illustrative and should be adapted to national IUCN GET classification choices. Where SEEA extent data directly populate inventory activity data, the workflow is straightforward. Where conversion factors or splits are needed, compilers should document the assumptions and, where possible, use country-specific emission factors developed in coordination with the national greenhouse gas inventory team. For deeper guidance on the relevant blue carbon ecosystems and their accounting, see **TG-6.2 Mangrove and Coastal Wetland Accounting** and **TG-6.3 Seagrass Accounts**.

¶7 **Adaptation indicators:** Ocean accounts can support monitoring of ecosystem-based adaptation by tracking:

- ¶8 Extent and condition of coastal protection ecosystems (coral reefs, mangroves, wetlands)
- ¶9 Coastal protection ecosystem services (flood mitigation, storm protection)
- ¶10 Economic dependencies on ocean ecosystem services

¶11 For guidance on disaster risk indicators derived from ocean accounts, see **TG-2.9 Disaster Risk and Resilience**. The linkage between ecosystem extent, condition, and coastal protection services provides a quantitative basis for valuing ecosystem-based adaptation investments.

3.5 BBNJ Agreement Indicators (Emerging horizon scanning)

¶1 The Agreement on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ Agreement) was adopted in June 2023 and entered into force on 17 January 2026, 120 days after the sixtieth ratification on 19 September 2025 [36]. The agreement establishes a legal framework for marine biodiversity in areas beyond national jurisdiction (ABNJ), including the high seas and the seabed beyond the continental shelf. The first Conference of the Parties is expected in 2026, at which detailed monitoring and reporting requirements will begin to be elaborated.

¶2 This section is presented as forward-looking horizon scanning rather than current operational guidance. No country currently has operational ocean accounts that extend into ABNJ, and the practical compilation of such accounts will require institutional and data-sharing arrangements that do not yet exist. The material below sets out (i) the relevant elements of the BBNJ Agreement, (ii) where ocean accounting concepts may eventually contribute, and (iii) the prerequisites that national statistics offices and partner institutions would need to address before ABNJ accounting becomes feasible.

Key elements of the BBNJ Agreement

¶1 The BBNJ Agreement addresses four main elements:

1. ¶2 Marine genetic resources and benefit-sharing
2. ¶3 Area-based management tools, including marine protected areas (Part III)
3. ¶4 Environmental impact assessments (Part IV)
4. ¶5 Capacity-building and technology transfer

Emerging indicator requirements

¶1 While the detailed monitoring framework for the BBNJ Agreement is still being developed through the Conference of the Parties process, ocean accounts can in principle contribute to:

¶2 **Marine genetic resources:** Physical flow accounts can record the extraction and use of marine genetic resources from ABNJ, including their incorporation into biotechnology and pharmaceutical products. Monetary flow accounts can track benefit-sharing arrangements [37]. The SEEA EA ecosystem services classification includes genetic material provisioning, which provides a methodological basis for this emerging requirement.

¶3 **Area-based management in ABNJ:** Ecosystem extent accounts can be extended to cover ecosystem types in ABNJ, including deep-sea ecosystems such as abyssal plains, hydrothermal vents, and seamounts. The IUCN Global Ecosystem Typology provides classifications for deep-sea ecosystem functional groups that can support extent accounting [38]. For guidance on deep-sea ecosystem accounting, see **TG-6.6 Deep Sea and ABNJ Accounts**.

¶4 **Environmental impact assessment:** The ecosystem condition and services accounting framework provides a structured approach to baseline assessment and impact monitoring that can inform environmental impact assessments in ABNJ. Condition reference levels can be established for minimally impacted deep-sea ecosystems against which project impacts can be assessed [39].

¶5 The SEEA EA acknowledges challenges for accounting in ABNJ, noting that for marine ecosystems "beyond the continental shelf…accounting may be challenging due to limited data availability and complex jurisdictional arrangements" [40].

Prerequisites for ABNJ accounting

¶1 Before national statistics offices can compile ocean accounts that extend meaningfully into ABNJ, several prerequisite arrangements need to be in place:

- ¶2 **Jurisdictional boundary protocols.** Clear delineation in the accounts between EEZ, extended continental shelf claims (where applicable), and ABNJ, using consistent maritime boundary

DRAFT

datasets (e.g., Marine Regions / VLIZ EEZ boundaries) and explicit treatment of overlapping or disputed claims.

- ¶3 **Institutional data access.** Data products from the International Seabed Authority (ISA) on deep-sea mining exploration contracts and environmental monitoring; data and stock-status outputs from Regional Fisheries Management Organisations (RFMOs) covering high-seas fisheries; and ocean observation products from IOC-UNESCO and the Global Ocean Observing System (GOOS).
- ¶4 **Scientific assessment inputs.** Periodic assessments from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the IOC-UNESCO World Ocean Assessment as a source of synthesised condition and pressure information for ABNJ.
- ¶5 **National mandate and inter-agency coordination.** A clear domestic mandate authorising the NSO (or a partner ocean agency) to compile statistics outside the EEZ, and inter-agency arrangements with foreign affairs, fisheries, and marine science institutions.

¶6 Until these prerequisites are in place, BBNJ-related ocean accounts should be treated as a development priority rather than a near-term reporting product. The accounting framework provides a methodological foundation that can be applied as data and governance arrangements develop.

3.6 Compilation Procedure: Worked Example

¶1 This section presents a synthetic worked example demonstrating how MEA indicators are derived from ocean account data through a step-by-step compilation procedure. The example focuses on a subset of indicators to illustrate the accounting-to-indicator workflow.

Context and scope

¶1 **Setting:** Hypothetical Coastal State (Country A) with an Exclusive Economic Zone (EEZ) of 250,000 km², including 5,000 km² of coral reef ecosystems and 12,000 km² of seagrass meadows. Country A has compiled ocean accounts for the 2024 reporting year and seeks to derive indicators for SDG 14.5.1 (MPA coverage), GBF Target 3 (protected area effectiveness), and SDG 14.3.1 (ocean acidification).

¶2 **Accounting period:** Calendar year 2024 (opening stock 1 January 2024, closing stock 31 December 2024).

¶3 **Data sources:** Ecosystem extent accounts from remote sensing analysis, ecosystem condition accounts from marine monitoring network, governance accounts from national MPA authority.

Step 1: Compile extent accounts by protection status

¶1 The first step involves compiling ecosystem extent accounts classified by IUCN protection category. Country A's extent account for coral reefs, disaggregated by protection status, appears as follows:

¶2 *Table 2: Ecosystem extent account for coral reefs by protection status (km²)*

Ecosystem type	IUCN I-II (Strict protection)	IUCN III-IV (Multiple use)	IUCN V-VI (Sustainable use)	Not protected	Total
Opening extent (1 Jan 2024)	400	800	600	3,200	5,000
Additions: New designations	50	100	0	-150	0
Reductions: De-listing	0	0	0	0	0
Closing extent (31 Dec 2024)	450	900	600	3,050	5,000

DRAFT

¶3 The extent account structure follows SEEA EA Table 4.1, with spatial classification disaggregated by IUCN protected area category as recommended in SEEA EA para 4.19. The "additions" and "reductions" rows record changes in protection status during the accounting period. In this example, Country A designated 150 km² of previously unprotected coral reef as protected areas during 2024 (50 km² as strict protection, 100 km² as multiple use).

Step 2: Derive SDG 14.5.1 indicator (coral subset)

¶1 SDG indicator 14.5.1 measures "Coverage of protected areas in relation to marine areas"[41]. The indicator is calculated as the ratio of protected area to total area:

¶2 **Formula:**

> *SDG 14.5.1 = (Total protected area / Total marine area) x 100*

¶3 **Calculation for Country A (coral reefs only):**

> *Protected coral reef area = 450 + 900 + 600 = 1,950 km² Total coral reef area = 5,000 km² Coverage = (1,950 / 5,000) x 100 = **39.0%***

¶4 This is a coral-reef-subset diagnostic measure, not the value submitted as the national SDG 14.5.1 figure, which is computed at the whole-EEZ level (see Step 2a).

Step 2a: Consolidated EEZ-level extent account and aggregated SDG 14.5.1

¶1 To produce the EEZ-level SDG 14.5.1 value, Country A consolidates its ecosystem extent accounts for all ecosystem types in the EEZ into a single multi-ecosystem extent account classified by protection status. This consolidation step follows the multi-ecosystem extent account template described in **TG-3.1 Asset Accounts** Section 3.4.2 and the spatial classification guidance in SEEA EA Chapter 4.

¶2 *Table 2B-Step2a: Consolidated EEZ-level extent account by protection status (km², closing extent 31 Dec 2024)*

Ecosystem type	IUCN I-VI (any protection)	Not protected	Total
Coral reefs (from Table 2)	1,950	3,050	5,000
Seagrass meadows	4,800	7,200	12,000
Other marine ecosystems (open water, soft sediment, pelagic)	80,000	153,000	233,000
EEZ total	**86,750**	**163,250**	**250,000**

¶3 The seagrass and other-ecosystem rows are produced from companion extent accounts compiled using the same protection-status classification used for coral reefs in Step 1. With the consolidated account in place, the EEZ-level SDG 14.5.1 value is:

> *Total protected marine area = 1,950 + 4,800 + 80,000 = 86,750 km² Total EEZ area = 250,000 km² Coverage = (86,750 / 250,000) x 100 = **34.7%***

¶4 The EEZ aggregate (34.7%) exceeds both the SDG 14.5 target of 10% and the GBF Target 3 goal of 30%. The coral-subset value (39.0%) and the EEZ-aggregate value (34.7%) measure different things on different denominators (5,000 km² coral reef versus 250,000 km² EEZ). Only the EEZ

DRAFT

aggregate is comparable with the official SDG 14.5.1 submission requirement, whilst the coral subset is a diagnostic tool for identifying within-EEZ protection gaps.

Step 3: Compile condition accounts for protected areas

¶1 To assess management effectiveness for GBF Target 3, Country A compiles ecosystem condition indicators for coral reefs, comparing protected and unprotected areas. The condition account records normalised indicators (scale 0-1) for key condition variables:

¶2 *Table 3: Ecosystem condition indicators for coral reefs by protection status (index 0-1)*

Condition variable	IUCN I-II	IUCN III-IV	IUCN V-VI	Not protected	Reference
Coral cover (structural state)	0.85	0.72	0.65	0.48	1.00
Fish biomass (compositional state)	0.80	0.68	0.60	0.42	1.00
Water quality (chemical state)	0.88	0.75	0.70	0.55	1.00
Species richness (compositional state)	0.82	0.70	0.63	0.50	1.00
Aggregate condition index (arithmetic mean)	**0.84**	**0.71**	**0.65**	**0.49**	**1.00**

¶3 The aggregate condition index uses an unweighted arithmetic mean of the four normalised indicators. This is a methodological choice with material consequences: arithmetic averaging implicitly assigns equal importance to each variable, treats them as substitutable, and can mask threshold breaches in any single variable (a low coral cover score may be offset by a high water quality score). Alternative aggregation methods — geometric mean (which penalises low scores more strongly), weighted arithmetic mean (which allows policy or ecological weighting), or minimum-value rules (which surface threshold breaches) — are discussed in **TG-2.1 Aggregate Biophysical Indicators** Section 3.6 and in the OECD Handbook on Constructing Composite Indicators (2008). Country A should document the chosen aggregation rule, the weighting (here, equal), and the reference condition basis as part of the metadata accompanying any cross-country comparison.

¶4 **Sensitivity check (geometric mean):** Applying a geometric mean to the four normalised indicators for the IUCN I-II column yields:

> *Geometric mean = (0.85 x 0.80 x 0.88 x 0.82)^(1/4) = (0.49069)^(0.25) ≈* ***0.836***

¶5 The geometric-mean condition index for IUCN I-II is 0.836 compared with the arithmetic-mean value of 0.84, close in this case because the four variables span a narrow range. The two aggregation rules would diverge more substantially in ecosystems where one variable is markedly lower than the others. This is exactly the case in which the choice of aggregation rule begins to affect policy interpretation. Countries comparing effectiveness scores across ecosystems or jurisdictions should therefore report the aggregation rule explicitly.

¶6 The reference column is 1.00 by construction. The reference condition for healthy coral reefs (based on historical data and marine reserve benchmarks, following the reference condition methodology described in **TG-2.1 Aggregate Biophysical Indicators** Section 3.4.2) is already applied when each variable is normalised, so a normalised indicator of 1 is the reference and the reference is not applied a second time.

Step 4: Derive a nationally-derived effectiveness metric (supporting GBF Target 3)

¶1 GBF Target 3 requires not only coverage but "effective" conservation. The CBD monitoring framework adopted in Decision 15/5 addresses effectiveness through a suite of headline, component, and complementary indicators drawing on the Management Effectiveness Tracking Tool (METT), the World Database on Protected Areas (WDPA), and IUCN Green List criteria, rather than

DRAFT

through any single ratio of condition indices. The metric computed below is therefore presented as a nationally-derived analytical metric for management assessment, not as the official GBF Target 3 effectiveness indicator submitted under the CBD monitoring framework.

¶2 Official GBF Target 3 effectiveness reporting should follow the METT-based and IUCN Green List approaches recognised in the CBD monitoring framework[42]. The account-derived condition ratio described here complements, but does not replace, those assessments.

¶3 **Formula (nationally-derived analytical metric):**

> *Nationally-derived effectiveness = (Protected area condition index / Reference condition index) x 100*

¶4 **Calculation for Country A:**

> *IUCN I-II = (0.84 / 1.00) x 100 =* ***84.0%*** *IUCN III-IV = (0.71 / 1.00) x 100 =* ***71.0%*** *IUCN V-VI = (0.65 / 1.00) x 100 =* ***65.0%*** *Not protected = (0.49 / 1.00) x 100 =* ***49.0%***

¶5 Area-weighted average across all protected coral reefs:

> *Weighted = [(450 x 0.840) + (900 x 0.710) + (600 x 0.650)] / 1,950 = [378.0 + 639.0 + 390.0] / 1,950 = 1,407.0 / 1,950 =* ***72.2%***

¶6 The area-weighted figure indicates that whilst 39% of coral reefs are protected, those protected areas achieve on average 72% of reference condition, a useful internal management signal. The differential across IUCN categories (84% for strict protection, 65% for sustainable use) informs management strategy. For external reporting against GBF Target 3, however, this figure should be transmitted as supplementary national analysis alongside the METT/Green List-based information that the CBD monitoring framework expects.

DRAFT

Step 5: Compile condition accounts for ocean acidification

¶1 For SDG indicator 14.3.1 (average marine acidity), Country A compiles pH measurements from its marine monitoring network. SDG 14.3.1 is a Tier II indicator under IOC-UNESCO custodianship and relies on data from an "agreed suite of representative sampling stations." The Global Ocean Acidification Observing Network (GOA-ON) provides the internationally recognised methodology for station design and data reporting against this indicator[43]. Country A's station network is therefore designed to satisfy GOA-ON minimum design criteria:

- ¶2 **Stratification by ecosystem zone.** Stations are distributed across coastal reef, seagrass zone, mid-shelf, outer shelf, and pelagic zones to capture the main acidification gradients within the EEZ rather than concentrating in a single zone.
- ¶3 **Minimum station density and replication.** At least two stations per ecosystem zone are recommended, with sufficient temporal sampling frequency to permit annual mean calculation with quantifiable uncertainty.
- ¶4 **Carbonate-chemistry consistency.** Stations report at minimum two of the four carbonate-system parameters (pH, total alkalinity, dissolved inorganic carbon, pCO2) under harmonised protocols, allowing cross-network comparability.

¶5 **Qualification for countries with sparse networks.** Countries that cannot currently meet GOA-ON station-density criteria can, as an interim measure, (i) participate in regional data-sharing arrangements (e.g., regional ocean acidification hubs) to pool station coverage, (ii) use spatial inter-

polation of available station data combined with remote-sensing-derived sea-surface temperature and salinity to estimate carbonate chemistry, or (iii) report the SDG 14.3.1 value with explicit metadata flags noting the network limitations. These interim approaches should be documented clearly so that data users understand the basis of the reported value.

¶6 The condition variable account records pH at 12 representative sampling stations across the EEZ:

¶7 *Table 4: Ocean pH measurements by station (2024 annual mean)*

Station ID	Location	pH (2024)	pH (2015 baseline)	Change
AZ-01	Coastal reef	8.05	8.12	-0.07
AZ-02	Coastal reef	8.03	8.10	-0.07
AZ-03	Seagrass zone	8.07	8.14	-0.07
AZ-04	Seagrass zone	8.06	8.13	-0.07
AZ-05	Mid-shelf	8.08	8.15	-0.07
AZ-06	Mid-shelf	8.09	8.16	-0.07
AZ-07	Mid-shelf	8.08	8.15	-0.07
AZ-08	Outer shelf	8.10	8.17	-0.07
AZ-09	Outer shelf	8.11	8.18	-0.07
AZ-10	Outer shelf	8.10	8.17	-0.07
AZ-11	Pelagic zone	8.12	8.19	-0.07
AZ-12	Pelagic zone	8.13	8.20	-0.07
Mean	—	**8.085**	**8.155**	**-0.07**

¶8 The uniform 0.07-unit change shown across all stations is a stylised feature of this worked example. In a real GOA-ON-aligned network, spatial heterogeneity in pH change between zones would be expected and is itself diagnostically useful.

DRAFT

Step 6: Derive SDG 14.3.1 indicator

¶1 SDG indicator 14.3.1 measures "Average marine acidity (pH) measured at agreed suite of representative sampling stations" [44] . The indicator is the arithmetic mean pH across all monitoring stations (computed in a manner consistent with the GOA-ON / IOC-UNESCO methodology referenced in Step 5):

¶2 **Calculation:**

> *SDG 14.3.1 = Sum of pH values / Number of stations = (8.05 + 8.03 + 8.07 + 8.06 + 8.08 + 8.09 + 8.08 + 8.10 + 8.11 + 8.10 + 8.12 + 8.13) / 12 = 97.02 / 12 =* ***8.085***

¶3 The 2024 mean pH of 8.085 represents a decline of 0.07 pH units relative to the 2015 baseline of 8.155, indicating a systematic acidification trend affecting the entire EEZ.

Step 7: Integrate indicators in combined presentation

¶1 The final step integrates the three derived indicators in a combined presentation that supports cross-MEA analysis:

¶2 *Table 5: Country A MEA indicator summary (2024)*

Indicator	Spatial scope	Value	Target	Status	Account source
SDG 14.5.1 (MPA coverage, coral subset — diagnostic)	Coral reef ecosystem only (5,000 km²)	39.0%	10% (SDG) / 30% (GBF)	Exceeds SDG, exceeds GBF (within coral subset)	Extent account (Table 2)
SDG 14.5.1 (MPA coverage, EEZ aggregate — official submission value)	Whole EEZ (250,000 km²)	34.7%	10% (SDG) / 30% (GBF)	Exceeds both	Consolidated extent account (Step 2a)
GBF Target 3 (nationally-derived effectiveness metric; supporting evidence only)	Protected coral reefs (1,950 km²)	72.2%	Higher effectiveness expected	Moderate; submit alongside METT / IUCN Green List information	Condition account (Table 3)
SDG 14.3.1 (Ocean pH)	EEZ-wide, 12 GOA-ON-aligned stations	8.085	Minimise decline	Declining (-0.07 since 2015)	Condition account (Table 4)

¶3 **Interpretive note on spatial scope.** Ecosystem-subset indicators (the coral-only MPA coverage figure) are diagnostic tools for identifying protection gaps within a specific ecosystem, whilst the whole-EEZ aggregate is the value comparable with the official SDG 14.5.1 submission requirement. National dashboards drawing on this table should always label the spatial scope of each indicator explicitly.

¶4 This combined presentation enables integrated analysis. Country A has met quantitative protection targets for both SDG 14.5 and GBF Target 3 at the EEZ level, but ecosystem-level analysis reveals that coral reef protection, whilst above 30%, still leaves 61% of reefs unprotected. The nationally-derived effectiveness metric of 72% suggests room for improvement in MPA management, to be reported as supporting information alongside METT or IUCN Green List assessments rather than as the official GBF Target 3 effectiveness value. Ocean acidification trends indicate a systematic pressure affecting all marine ecosystems regardless of protection status. Addressing that pressure requires climate mitigation action of the kind addressed through UNFCCC/Paris Agreement commitments.

DRAFT

Principle	Description
Custodian alignment and supplementary metrics	Several MEA indicators have designated custodian methodologies (FAO for 14.4.1/14.7.1, IOC-UNESCO for 14.3.1, CBD/METT for GBF Target 3 effectiveness); account-derived figures that do not match the custodian formula should be clearly positioned as nationally-derived supplementary metrics or as inputs to the official compilation, not as substitutes.
Reference conditions and aggregation choices	Condition-based indicators require documented reference levels for normalisation; composite indices require a reported aggregation rule (arithmetic mean, geometric mean, weighted, minimum) so that cross-country comparisons remain interpretable.
Combined presentations	Integrated indicator tables support cross-MEA analysis, revealing complementarities (MPA coverage supports both SDG 14.5 and GBF Target 3) and tensions (acidification affects all ecosystems regardless of protection status); spatial scope must be labelled explicitly for each indicator to avoid denominator-mismatch misinterpretation.

3.7 MEA-Account Alignment

¶1 For a structured cross-walk between MEA reporting frameworks and ocean account types, see the relevant subsection: Section 3.2 (SDG 14), Section 3.3 (GBF), Section 3.4 (Paris Agreement/NDCs), Section 3.5 (BBNJ).

¶2 **Reporting frequency harmonisation.** Different MEAs operate on different reporting cycles. SDG Voluntary National Reviews are typically annual or biennial, GBF national reporting is biennial, and NDC updates follow a five-year ratchet with biennial transparency reporting. Where annual compilation is not feasible, mid-cycle GBF indicators should use the most recently compiled account year, and the reference year of the underlying account data should be documented explicitly in the national metadata submitted with each report.

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

5. References

1. ¶1 SEEA EA, Preface, para 4.
2. ¶2 SEEA EA, para 14.7. "An indicator is the representation of data for a specified time, place or any other relevant characteristic, corrected for at least one dimension (usually size) so as to allow for meaningful comparisons."
3. ¶3 SEEA EA, para 14.8.
4. ¶4 SEEA EA, para 14.14.
5. ¶5 Official Records of the Economic and Social Council, 2020, Supplement No. 4 (E/2020/24), chap. I, sect. C, decision 51/101, para. (g).
6. ¶6 SEEA EA, para 14.30. "The monitoring framework for the Kunming-Montreal Global Biodiversity Framework draws directly on SEEA EA for several indicators, including the headline indicators under goals A and B."
7. ¶7 SEEA EA, para 14.28.
8. ¶8 SEEA EA, para 14.28. SEEA enables countries to use a single, coherent database for reporting to multiple monitoring frameworks.
9. ¶9 TNFD (2023). *Recommendations of the Taskforce on Nature-related Financial Disclosures*. Executive Summary, p.12. "The TNFD recommendations are designed to be aligned with the global policy goals and targets in the GBF, including Target 15 on corporate reporting of nature-related risks, dependencies and impacts."
0. ¶10 United Nations General Assembly Resolution 70/1, The 2030 Agenda for Sustainable Development, Goal 14.
1. ¶11 Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development, A/RES/71/313, Annex. Refinements adopted through annual IAEG-SDGs review process.
2. ¶12 Compiled from Global SDG Indicator Framework, Goal 14, as refined through the 2024 comprehensive review by the IAEG-SDGs.
3. ¶13 SEEA CF, Chapter III, Physical Flow Accounts. "Physical flow accounts record flows of natural inputs, products, and residuals within the economy and between the economy and the environment."
4. ¶14 UNEP, SDG indicator metadata 14.2.1 (last updated 29 July 2024), and UNEP (2021), *Understanding the State of the Ocean: A Global Manual on Measuring SDG 14.1.1, SDG 14.2.1 and SDG 14.5.1*. UNEP is the custodian; IOC-UNESCO and FAO are partner agencies (IAEG-SDGs, Tier Classification for Global SDG Indicators, 10 April 2025). The indicator value is generated through a national survey instrument administered by the custodian agency.
5. ¶15 SEEA EA, Chapter 13, Section 13.5 on Ocean Accounts.
6. ¶16 SEEA EA, para 5.14, Class B: Chemical state characteristics "including nutrient levels, carbon, pollutant concentrations, and salinity".
7. ¶17 FAO (2022), SDG Indicator 14.4.1 Metadata. The official methodology classifies stocks into status categories from national stock assessment reports rather than from a direct biomass-to-BMSY ratio.
8. ¶18 SEEA CF, para 5.393-5.458, Aquatic Resources. The SEEA CF notes that "for any given population, it is possible to calculate the number of animals or volume of plants…that may be removed from the population without affecting the capacity of the population to regenerate itself" (para 5.82).
9. ¶19 SEEA EA, Chapter 4, Section 4.2 on ecosystem extent accounts. Extent accounts can be disaggregated by spatial classifications including protected area status.
0. ¶20 FAO (2024), SDG Indicator 14.7.1 Metadata (IAEG-SDGs metadata repository, 2024 revision). The official composite uses sustainability-weighted catch and value-added information rather than a simple supply-use-derived ratio.
1. ¶21 SEEA EA, Chapter 9, Monetary Ecosystem Services Flow Accounts, and Chapter 11, Extended accounts and indicators.
2. ¶22 CBD Decision 15/4, Kunming-Montreal Global Biodiversity Framework. Adopted at COP-15, Montreal, December 2022.
3. ¶23 SEEA EA, Appendix A14.1, Table A14.1.1.
4. ¶24 Kunming-Montreal Global Biodiversity Framework, Target 2.

DRAFT

5. ¶25 SEEA EA, Appendix A14.1, Table A14.1.2, Target 2. "Target 2, which monitors the area of degraded ecosystems under ecosystem restoration, can be informed by indicators deriving from a combination of ecosystem extent accounts and ecosystem condition accounts of SEEA EA."
6. ¶26 Kunming-Montreal Global Biodiversity Framework, Target 3.
7. ¶27 Kunming-Montreal Global Biodiversity Framework, Target 15. The full text states: "Encourage and enable business, and in particular to ensure that large and transnational companies and financial institutions, regularly monitor, assess, and transparently disclose their risks, dependencies and impacts on biodiversity."
8. ¶28 Taskforce on Nature-related Financial Disclosures, Final Recommendations, September 2023.
9. ¶29 TNFD v1.0 Technical Guidance on alignment with SEEA, September 2023; TNFD Additional Sector Guidance — Fishing (draft June 2024, updated 2025) and related supplementary materials covering marine sectors.
0. ¶30 TNFD Final Recommendations, p.12.
1. ¶31 Paris Agreement, Article 2.
2. ¶32 SEEA EA, Table 6.3 and para 13.56 on global climate regulation services.
3. ¶33 SEEA EA, para 6.43-6.52, Global climate regulation services.
4. ¶34 SEEA EA, Chapter 13, paras 13.56-13.61 on global climate regulation services. The global climate regulation service associated with carbon sequestration and storage is the annual flow of carbon sequestered by ecosystem types, measured in physical terms.
5. ¶35 SEEA EA, Preface, para 4. See also IPCC (2014), 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, Chapter 4, on activity data requirements for coastal wetlands.
6. ¶36 Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction, adopted 19 June 2023. Entered into force 17 January 2026, 120 days after the sixtieth ratification on 19 September 2025.
7. ¶37 BBNJ Agreement, Part II, Marine Genetic Resources.
8. ¶38 IUCN Global Ecosystem Typology, Realm M (Marine), Biome M3 (Deep sea floors) including M3.1 Continental and island slopes, M3.2 Submarine canyons, M3.3 Abyssal plains, M3.4 Seamounts, ridges and plateaus, M3.5 Deepwater biogenic beds, M3.6 Hadal floors and trenches.
9. ¶39 SEEA EA, para 5.35-5.48, Reference conditions. "Reference conditions should reflect the expected condition of an ecosystem type in the absence of human-induced degradation."
0. ¶40 SEEA EA, para 13.56.
1. ¶41 United Nations (2017). *Global Indicator Framework for the Sustainable Development Goals*. A/RES/71/313. Indicator 14.5.1.
2. ¶42 CBD Decision 15/5, Annex on the Monitoring Framework for the Kunming-Montreal Global Biodiversity Framework (2022); METT v4.0; IUCN Green List of Protected and Conserved Areas Standard.
3. ¶43 IOC-UNESCO / Global Ocean Acidification Observing Network (GOA-ON), Methodology for SDG Indicator 14.3.1 (Tier II).
4. ¶44 United Nations (2017). *Global Indicator Framework for the Sustainable Development Goals*. A/RES/71/313. Indicator 14.3.1.

DRAFT

Resource Efficiency Indicators

Provides guidance on compiling resource efficiency indicators from ocean accounts: ratios that relate economic outputs to physical resource inputs.

Version 0.7.2 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

OUTCOME

This Circular provides guidance on compiling resource efficiency indicators from ocean accounts: ratios that relate economic outputs to physical resource inputs and indicate how effectively ocean industries transform natural capital into economic value. Indicators compiled using this guidance feed directly into budget and planning processes described in TG-1.1 Budget Processes.
Prerequisites and cross-references are listed in Section 2.
Upon completing this Circular, readers will understand (1) the conceptual framework for resource efficiency indicators, (2) compilation procedures for deriving material efficiency indicators for fish, water, and energy, (3) methods for computing decoupling indicators that track the relationship between economic growth and resource use, (4) approaches to circular economy indicators for waste, recycling, and resource recovery, and (5) practical applications to sector-specific efficiency metrics for fisheries, aquaculture, maritime transport, and offshore energy.

DRAFT

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 3
3.1 Resource Efficiency Framework 4
3.2 Material Efficiency Indicators 6
3.3 Decoupling Indicators 8
3.4 Circular Economy Indicators 11
3.5 Sector-Specific Efficiency Indicators 13
3.6 Compilation Procedure 15
3.7 Worked Examples 17
4. Acknowledgements 22
5. References 22

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Resource Efficiency Indicators (2026) (GOAP Technical Guidance on Ocean Accounting, TG-2.11, v0.7.2). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-2/2-11-resource-efficiency/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

¶1 **Framework Position**

¶2 TG-2.11 sits at the intersection of the monetary accounts (Section 3) and indicator synthesis (Section 2). It draws on physical flow data from TG-3.2 and economic measures from TG-3.3 to produce efficiency ratios that are consumed by TG-1.1 for budget policy reporting. Compilers who have not yet completed TG-3.3 should do so before applying this Circular.

1. Outcome

¶1 This Circular provides guidance on compiling resource efficiency indicators from ocean accounts: ratios that relate economic outputs to physical resource inputs and indicate how effectively ocean industries transform natural capital into economic value. Indicators compiled using this guidance feed directly into budget and planning processes described in **TG-1.1 Budget Processes**. Prerequisites and cross-references are listed in Section 2.

¶2 Upon completing this Circular, readers will understand (1) the conceptual framework for resource efficiency indicators, (2) compilation procedures for deriving material efficiency indicators for fish, water, and energy, (3) methods for computing decoupling indicators that track the relationship between economic growth and resource use, (4) approaches to circular economy indicators for waste, recycling, and resource recovery, and (5) practical applications to sector-specific efficiency metrics for fisheries, aquaculture, maritime transport, and offshore energy.

2. Requirements

¶1 This Circular requires familiarity with:

- ¶2 **TG-0.1 General Introduction to Ocean Accounts** – for the conceptual framework connecting ecosystems, flows, and economic activity
- ¶3 **TG-0.2 Overview of Relevant Statistical Standards** – for the international statistical standards underpinning ocean accounting, including SNA 2025, SEEA CF, and classification systems
- ¶4 **TG-3.3 Economic Activity** – for the economic measures (output, value added, GDP) that serve as the numerator in efficiency indicators, and for supply and use table structures that provide coherent economic data

¶5 For additional context on physical flow accounting, see **TG-3.2 Flows from Environment to Economy**. For guidance on linking efficiency indicators to environmental asset stocks, see **TG-3.1 Asset Accounts**. For guidance on residual flows that inform circular economy indicators, see **TG-3.4 Flows from Economy to Environment**.

3. Guidance Material

¶1 The SEEA Central Framework identifies resource efficiency and productivity indicators as a key application of environmental-economic accounting, noting that topics covered include "resource efficiency and productivity indicators, decomposition analysis, analysis of net wealth and depletion, sustainable production and consumption, input-output analysis and general equilibrium modelling"[1]. The SEEA Applications and Extensions publication provides additional detailed guidance on constructing and interpreting resource efficiency indicators within the environmental-economic accounting framework. Compilers should consult that publication alongside this Circular for extended methodological guidance[2].

¶2 This circular covers four resource efficiency indicator types (material efficiency, energy intensity[3], water intensity[4], and decoupling). Material, energy and water efficiency are covered in

Section 3.2 and decoupling in Section 3.3; Sections 3.4 and 3.5 add circular economy and sector-specific indicators.

3.1 Resource Efficiency Framework

¶1 Resource efficiency indicators express the relationship between economic outputs and natural resource inputs. The SEEA Central Framework establishes that combined presentations of physical and monetary data "structure information in a manner that supports the derivation of combined indicators, for example, decoupling indicators which track the relationship between the use of resources and growth in production and consumption" [5].

Decision use cases

¶1 Resource efficiency indicators for the ocean economy serve four primary decision contexts:

¶2 **Circular ocean economy tracking** — governments committed to circular economy transitions require indicators that demonstrate whether ocean industries are reducing material throughput per unit of output, increasing recycling and reuse rates, and closing material loops. The European Commission's Circular Economy Action Plan and similar national strategies call for monitoring progress through material flow indicators, waste generation rates, and recycling performance metrics [6].

¶3 **Decoupling analysis** — SDG Target 8.4 explicitly requires countries to "improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation" [7]. Resource efficiency indicators provide the empirical evidence to demonstrate whether ocean economy growth is accompanied by declining resource intensity (relative decoupling) or absolute reductions in resource extraction (absolute decoupling).

¶4 **SDG 12 reporting** — SDG Target 12.2 calls for achieving "sustainable management and efficient use of natural resources" by 2030 [8]. The SDG indicator framework includes material footprint per capita and per GDP (indicators 8.4.1 and 12.2.1) as headline measures of progress [9]. Ocean economy resource efficiency indicators contribute directly to national reporting under these frameworks.

¶5 **Green growth measurement** — ministries of finance and planning agencies require evidence that ocean economy growth is compatible with environmental sustainability objectives. Resource efficiency indicators provide quantified metrics for budget presentations, medium-term expenditure frameworks, and national development plans [10].

Basic indicator structure

¶1 Resource efficiency indicators follow a general ratio structure:

> *Resource Efficiency = Economic Output / Resource Input*

¶2 Where:

- ¶3 **Economic output** may be measured as gross value added (GVA), gross output, or GDP, drawn from the economic accounts described in **TG-2.5 Ocean Economy Structure** and **TG-3.3 Economic Activity**
- ¶4 **Resource input** is measured in physical terms: tonnes of fish extracted, cubic metres of water abstracted, or joules of energy consumed, drawn from physical flow accounts described in **TG-3.2 Flows from Environment to Economy**

¶5 The reciprocal formulation—resource intensity—expresses resource input per unit of economic output:

DRAFT

> *Resource Intensity = Resource Input / Economic Output*

¶6 Both formulations provide valid analytical perspectives. Resource efficiency emphasises productivity gains (higher values indicate improvement), whilst resource intensity emphasises resource requirements (lower values indicate improvement). The SEEA Energy notes that "indicators of energy efficiency, energy expenditures by different industries and households, and energy intensity" can be derived through combined presentations[11].

Selecting the economic measure

¶1 The choice of economic measure in the numerator (or denominator for intensity indicators) affects interpretation and should be made deliberately. Three principal measures are available from the ocean economy thematic and extended accounts described in **TG-3.3 Economic Activity** Section 3.4:

- ¶2 **Gross value added (GVA)** is typically preferred for industry-level analysis because it excludes intermediate consumption, providing a cleaner measure of the value created by an industry from its resource inputs. GVA enables comparison across industries of different sizes and structures. The derivation of GVA from supply and use tables is described in **TG-2.5** Section 3.7.
- ¶3 **Gross output** may be more appropriate for productivity analysis within a single industry, as it captures the total volume of production and thus better reflects physical throughput. However, gross output can be inflated by high intermediate consumption, potentially misrepresenting efficiency.
- ¶4 **GDP** is appropriate only for economy-wide analysis of the total ocean economy's resource efficiency, as it aggregates across all industries.

¶5 Compilers should document which economic measure is used and ensure consistency across time series.

Dimensions of resource efficiency

¶1 Resource efficiency can be analysed across the dimensions summarised in Table 3.1.1 below.[12]

Dimension	Description
Material efficiency	The physical quantity of natural resources (fish, minerals, water) required per unit of economic output.
Energy efficiency	The quantity of energy required per unit of economic output or per unit of physical output.
Water efficiency	The volume of water abstracted or consumed per unit of economic output.
Carbon efficiency	Greenhouse gas emissions per unit of economic output (addressed in **TG-2.8 Climate Indicators**).

¶2 For ocean accounting, material efficiency is particularly relevant for fisheries and mineral extraction, energy efficiency for maritime transport and offshore energy, and water efficiency for aquaculture and coastal industries.

Resource Efficiency Indicator Specifications

¶1 This circular covers four resource efficiency indicator types (material efficiency, energy intensity, water intensity, and decoupling). Material, energy and water efficiency are covered in Section 3.2 and decoupling in Section 3.3; Sections 3.4 and 3.5 add circular economy and sector-specific indicators.

Analytical levels

DRAFT

¶1 Resource efficiency indicators can be compiled at the analytical levels summarised in Table 3.1.2 below.

Level	Description
Economy-wide	Comparing total ocean economy GVA to total ocean resource use.
Industry-level	Comparing value added or output for specific ocean industries (fishing, shipping, offshore energy) to resource inputs for those industries.
Establishment-level	Comparing output of individual enterprises to their resource consumption (typically available only through survey or administrative data).

¶2 The industry-level analysis is typically most useful for policy, as it reveals differential efficiency across ocean sectors and identifies opportunities for improvement. The SEEA Energy provides example analyses at the industry level, showing "energy intensities for selected industries" that enable comparison across sectors [13].

¶3 When moving between analytical levels, compilers must observe the following aggregation rules. Efficiency ratios must never be averaged across industries. Averaging ratio values produces misleading results because the importance of each industry (its share of total resource use and total output) is not preserved. Economy-wide indicators must instead be computed by summing the numerator and denominator separately across all relevant industries, then computing the aggregate ratio from those sums. For example, the correct economy-wide fish productivity indicator is total fishing-sector GVA divided by total gross catch — not the average of individual fleet or sub-sector fish productivity ratios. **Cross-resource aggregation** combines fish productivity, energy intensity, and water productivity into a single composite efficiency score. This is not supported by SEEA methodology and should not be attempted without an explicit weighting framework such as environmental cost weights derived from SEEA Ecosystem Accounts. To illustrate the correct approach: if Industry A has GVA of 100 and resource input of 50, and Industry B has GVA of 400 and resource input of 300, the correct aggregate efficiency is (100 + 400) / (50 + 300) = 1.43, not the average of the two industry ratios (2.0 and 1.33), which yields 1.67 — an overestimate that misrepresents the aggregate productivity of the sector.

DRAFT

3.2 Material Efficiency Indicators

¶1 Material efficiency indicators measure the relationship between physical resource extraction and economic output. For ocean resources, the primary materials of interest are fish and other aquatic biomass, seawater (for desalination and industrial use), and seabed minerals.

Fish productivity

¶1 Fish productivity indicators relate the value of fishing industry output to the physical quantity of fish extracted. Following SEEA CF guidance on aquatic resources [14], the key physical measure is **gross catch**—the total live weight of fish caught, including discarded catch but excluding pre-catch losses. This measure aligns with the physical flow accounts described in **TG-3.2 Flows from Environment to Economy**.

¶2 Key fish productivity indicators include:

¶3 **Value added per tonne of catch** — the gross value added of the fishing industry divided by total catch weight:

> *Fish Productivity ($/tonne) = Fishing Industry GVA / Gross Catch (tonnes)*

¶4 This indicator reveals how much economic value is generated per unit of fish extracted. Higher values may indicate higher-value species composition, more value-added processing, or improved market access. However, compilers should be aware that high economic efficiency is compatible

with overfishing if prices rise as stocks decline—a phenomenon that can occur when scarcity drives up market prices for depleted species. For this reason, fish productivity indicators should always be interpreted alongside sustainability indicators. SDG indicator 14.4.1 measures "proportion of fish stocks within biologically sustainable levels"[15], and the fisheries stock assessment methods described in **TG-6.7 Fisheries Stock Assessment** provide complementary measures of biological sustainability.

¶5 **Fallback hierarchy for discard data unavailability.** In many developing economies and some developed ones, official fisheries statistics record only landed weight. Discard estimates are produced by fisheries science bodies rather than national statistics offices and may not be available for all fisheries. Compilers should apply the following fallback hierarchy:

1. ¶6 **Gross catch (preferred)** — use total live weight including discards where observer programme data or scientific discard estimates are available. This is the measure recommended by SEEA CF paras 5.428–5.429.
2. ¶7 **Landed catch with documentation** — where discard data do not exist, substitute landed catch and document the indicator as "landed fish productivity" rather than "gross catch productivity." This note must appear in the metadata and the indicator table.
3. ¶8 **Bounded estimate** — where partial discard data exist (for example, observer coverage for trawl fleets only), compute a bounded estimate using the observed discard rate as a lower bound and an assumed upper bound from comparable fisheries, and report the resulting range explicitly.

¶9 Where discard data are systematically unavailable, compilers should consult **TG-6.7 Fisheries Stock Assessment** for stock assessment-based discard estimates that can supplement national statistics office data.

¶10 **Catch per unit of effort (CPUE)** — whilst not strictly an economic efficiency indicator, CPUE relates physical catch to fishing effort and provides insight into the productivity of fishing operations and the abundance of fish stocks. CPUE is addressed in detail in **TG-6.7 Fisheries Stock Assessment**.

¶11 **Sustainable yield ratio** — comparing actual extraction to estimated maximum sustainable yield (MSY) for managed fish stocks, providing a complementary perspective on resource sustainability.

DRAFT

Water productivity

¶1 Water productivity indicators relate economic output to water abstraction and consumption. The SEEA-Water framework provides detailed guidance on water intensity and productivity measurement[16].

¶2 For ocean contexts, relevant water productivity indicators include:

¶3 **Aquaculture water productivity** — the value added of aquaculture production divided by water use. The appropriate water use measure depends on the aquaculture system type. Compilers must not make cross-system comparisons without normalising to a consistent consumption basis:

System type	Denominator definition	Formula
Flow-through (ponds, raceways)	Water abstraction (intake volume)	Aquaculture GVA / Water abstraction (m^3)
Recirculating aquaculture systems (RAS) and closed ponds	Actual water consumption (abstraction minus return flows)	Aquaculture GVA / Water consumption (m^3)

¶4 The distinction between abstraction and consumption follows the SEEA-Water framework. Compilers should consult SEEA-Water Annex 3 Table A3.2 for the precise consumptive-use calculation methodology[17]. Using an intake-volume denominator for RAS systems, which recycle 90–99% of water internally, would produce artificially high water productivity figures that are not comparable with flow-through systems. Compilers working with mixed technology portfolios should

present system-specific productivity figures separately and note that aggregate comparisons require normalisation to consumption basis.

¶5 This indicator is relevant for aquaculture operations where water efficiency is a management priority[18], as described in **TG-3.9 Aquaculture Accounts**.

¶6 **Desalination efficiency** — the ratio of freshwater output to energy input in desalination operations, relevant for coastal communities dependent on desalination.

¶7 **Industrial water intensity** — for coastal industries using seawater for cooling or processing, the volume of water abstracted per unit of output.

Energy productivity

¶1 Energy productivity indicators relate economic output to energy consumption. The SEEA Energy framework provides extensive guidance on energy intensity indicators[19].

¶2 Key ocean-related energy productivity indicators include:

¶3 **Maritime transport energy intensity** — energy consumption per tonne-kilometre of freight or per passenger-kilometre:

> *Shipping Energy Intensity = Energy Use (joules) / Transport Output (tonne-km)*

¶4 This indicator is central to monitoring decarbonisation progress in the maritime sector and relates to climate indicators described in **TG-2.8 Climate Indicators**. Energy intensity indicators for maritime transport must be disaggregated by fuel type to support decarbonisation tracking. Aggregating all fuel types into a single joules figure masks fuel substitution trends: a vessel switching from heavy fuel oil to liquefied natural gas (LNG) may show declining energy intensity under a single-fuel metric even if actual greenhouse gas emissions do not decline proportionally. Compilers should therefore report three sub-indicators for maritime transport energy intensity:

- ¶5 **(a) Total energy intensity** — all fuels expressed in tonnes of oil equivalent (toe), used for overall productivity comparisons;
- ¶6 **(b) Fossil energy intensity** — petroleum products and natural gas only, in toe, used for tracking fossil fuel dependency;
- ¶7 **(c) Renewable energy share** — the proportion of total energy consumption sourced from renewables (biofuels, shore power, wind assist, hydrogen), expressed as a percentage.

¶8 The fuel-type classification follows SEEA Energy Chapter 4 on energy supply and use tables[20]. Total energy intensity alone is insufficient for decarbonisation tracking and must be supplemented by the fuel-type decomposition above and the GHG emission indicators described in **TG-2.8 Climate Indicators**.

¶9 **Offshore energy extraction efficiency** — for offshore oil and gas, the ratio of energy extracted to energy consumed in extraction operations (energy return on energy invested, or EROEI). See **TG-3.10 Offshore Energy Accounts** for detailed guidance.

¶10 **Fishing fleet fuel efficiency** — fuel consumption per tonne of catch, relevant for both cost efficiency and greenhouse gas emission reduction.

¶11 The SEEA Energy notes that energy use combined with economic data enables derivation of "energy use per unit of GDP"[21], which can be adapted to the ocean economy by relating ocean sector energy use to ocean sector GVA.

3.3 Decoupling Indicators

¶1 Decoupling indicators track the relationship between economic growth and resource use over time. They indicate whether an economy is achieving more output with less environmental

DRAFT

pressure [22]. SDG Target 8.4 explicitly calls upon countries to "improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation" [23].

Concept of decoupling

¶1 **Decoupling** occurs when the growth rate of an environmental variable (resource use, emissions, waste generation) is lower than the growth rate of the relevant economic variable (GDP, value added, output) [24]. Two forms are distinguished:

1. ¶2
   Relative decoupling — the environmental variable continues to grow, but at a slower rate than economic output. Resource intensity declines, but total resource use increases.
2. ¶3
   Absolute decoupling — the environmental variable declines in absolute terms whilst economic output grows. This represents genuine reduction in environmental pressure alongside economic growth.

Computing decoupling indicators

¶1 A decoupling factor can be computed as:

> *Decoupling Factor = 1 - (Resource Use Growth Rate / Economic Output Growth Rate)*

¶2 Where:

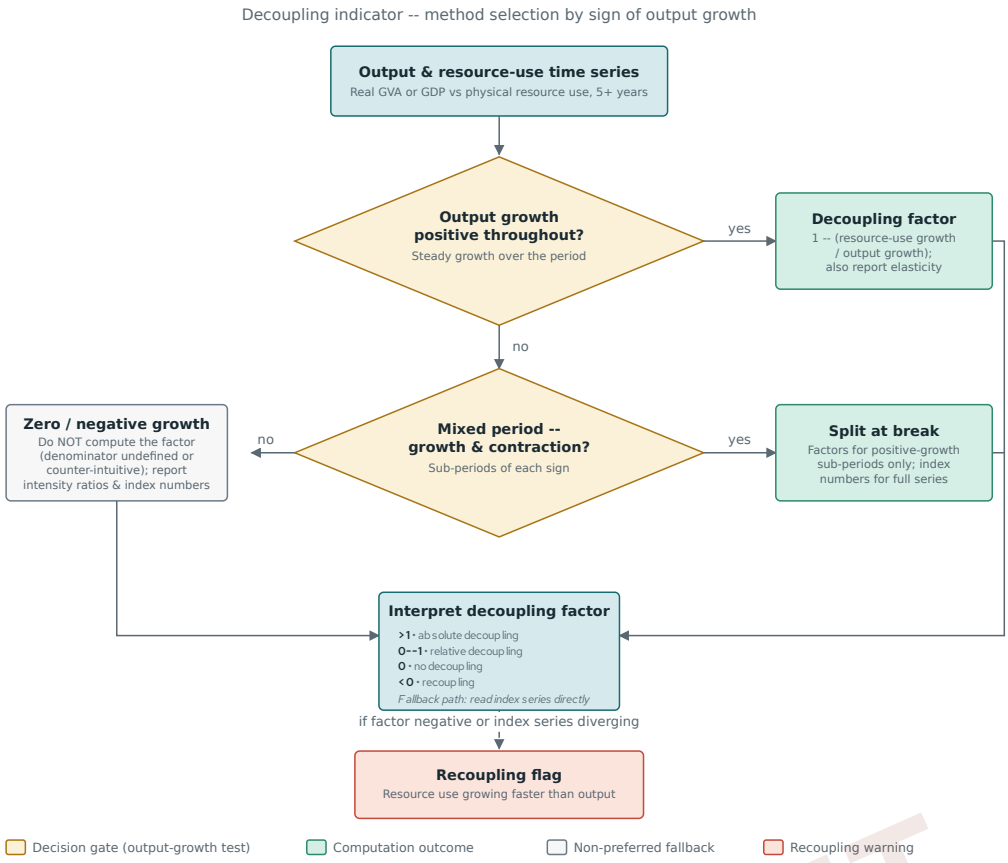
- ¶3 A positive decoupling factor indicates relative decoupling
- ¶4 A decoupling factor > 1 indicates absolute decoupling
- ¶5 A negative factor indicates increasing resource intensity ("recoupling")
- ¶6 A decoupling factor of zero indicates no decoupling — resource use is growing at the same rate as economic output

DRAFT

¶7 These interpretation rules apply when economic output growth is positive. When economic output growth is zero or negative, the decoupling factor must not be computed. Dividing by zero produces an undefined result. Dividing by a negative denominator produces counter-intuitive values that can spuriously indicate absolute decoupling during a recession merely because resource use declined faster than output. In such periods, compilers should instead report:

- ¶8 **Resource intensity ratios** (Section 3.1) for the affected years, showing the physical input per unit of output without reference to growth rates;
- ¶9 **Year-on-year percentage changes** in both the economic and physical series separately;
- ¶10 **Index numbers** (base year = 100 for both series) as the recommended visualisation for multi-year periods that include non-growth episodes. The index-number approach avoids the zero-denominator problem and allows visual comparison of trajectories without computing a ratio of growth rates.

¶11 Figure 2.11.1 summarises the recommended approach, keying the method choice to the sign of economic-output growth: (1) positive growth throughout routes to the decoupling factor, (2) a mixed period is split at the structural break, and (3) zero or negative growth follows the fallback, in which the factor must not be computed and intensity ratios and index-number series are reported instead.



DRAFT

Figure 2.11.1 Decoupling measurement follows a decision tree keyed to the sign of economic-output growth. Positive-growth branch yields a Tapio-style factor; zero/negative growth redirects to intensity ratios and index series.

Source: TG-2.11 Resource Efficiency Indicators, §3.3 (decoupling decision tree and zero/negative-growth fallback).

Adapted from: Tapio (2005) decoupling typology; OECD (2002) *Indicators to Measure Decoupling of Environmental Pressure from Economic Growth*; SEEA Central Framework Ch. 7 (combined physical-monetary indicator derivation); SDG Target 8.4.

¶12 Alternatively, an elasticity formulation expresses the responsiveness of resource use to economic growth:

> *Resource Elasticity = % Change in Resource Use / % Change in Economic Output*

¶13 An elasticity less than 1 indicates relative decoupling. A negative elasticity with positive economic growth indicates absolute decoupling. Note that the same zero-denominator constraint applies: the elasticity formulation is undefined when economic output growth is zero.

Base-year selection and sensitivity testing

¶1 Decoupling indicators are sensitive to the choice of base year and comparison period. Compilers must observe the following requirements:

- ¶2 **Base year selection** — the recommended base year for a decoupling assessment is the year prior to the major national ocean economy policy intervention or plan under evaluation (for example, the year before a national ocean policy was enacted). This anchors the decoupling assessment to the period of policy relevance.

- ¶3 **Sensitivity testing** — compilers must test at least two alternative base years and report the resulting range of decoupling factor values as a sensitivity check. If the sign or magnitude of the decoupling factor changes materially across alternative base years, this must be flagged in the methodological notes accompanying the published indicator.
- ¶4 **Standardised comparison intervals** — snapshot comparisons should use evenly spaced periods (for example, five-year intervals aligned to the national development plan cycle) rather than intervals of different length. Uneven intervals produce decoupling factors that cannot be compared across resources or across countries.
- ¶5 **Rolling averages and minimum horizons** — for cyclical industries such as fishing, three-year or five-year rolling averages should be used to smooth annual variability. Decoupling assessments generally require at least five years of data to distinguish genuine structural trends from short-term fluctuations, and ten or more years are preferable.
- ¶6 **Structural breaks** — see the guidance on structural breaks in the time series below.

Structural breaks in the time series

> ¶1 ⚠ **Structural breaks in the time series**
> ¶2 Do not use structural break years as decoupling analysis endpoints. Common causes of structural breaks in ocean economy time series include pandemic-related economic contractions (e.g., 2020 COVID-19), major fisheries collapses or stock recovery events, policy changes that alter reporting practices, and natural disasters affecting coastal infrastructure. When a structural break year falls within the analysis period, compilers must: (a) flag the year in indicator metadata with a description of the cause, (b) report pre-break and post-break series separately, with decoupling factors computed within each sub-period, and (c) avoid computing a single decoupling factor that spans the break year as an endpoint. Including a crisis year as an endpoint can produce spurious decoupling results in either direction.

Ocean economy decoupling indicators

¶1 For ocean accounting, key decoupling indicators include:

¶2 **Fish extraction decoupling** — comparing growth in fishing industry GVA to growth in fish catch tonnage:

> *Fish Decoupling Factor = 1 - (Fish Catch Growth Rate / Fishing GVA Growth Rate)*

¶3 Positive values indicate that the fishing sector is generating more value from each tonne of fish extracted—potentially through higher prices, better species mix, or more value-added processing. This indicator should be interpreted alongside stock sustainability indicators from **TG-6.7 Fisheries Stock Assessment**.

¶4 **Maritime emissions decoupling** — comparing growth in shipping sector GVA to growth in greenhouse gas emissions:

> *Shipping Emissions Decoupling = 1 - (Emissions Growth Rate / Shipping GVA Growth Rate)*

¶5 This indicator tracks progress toward the International Maritime Organization's decarbonisation goals and relates to the climate indicators described in **TG-2.8 Climate Indicators**.

¶6 **Material footprint decoupling** — SDG indicators 8.4.1 and 12.2.1 measure material footprint (per capita and per GDP)[25], which can be computed for ocean-related materials to track decoupling at the economy-wide level.

3.4 Circular Economy Indicators

DRAFT

¶1 Circular economy indicators measure the extent to which economic systems reduce waste, reuse materials, and recycle resources, moving from linear "take-make-dispose" models toward circular flows. SDG Target 12.5 aims to "substantially reduce waste generation through prevention, reduction, recycling and reuse" [26].

Circular economy concepts

¶1 For ocean sectors, circular economy principles apply as summarised in Table 3.4.1 below. [27]

Sector	Circular Economy Applications
Fishing and aquaculture	Reducing discards and bycatch, utilising fish processing waste for feed or other products.
Maritime transport	Extending vessel lifetimes, recycling ship materials at end of life.
Offshore energy	Decommissioning and recycling offshore platforms, repurposing infrastructure.

¶2 These applications relate to the flows from economy to environment described in **TG-3.4 Flows from Economy to Environment**.

Waste and recycling indicators

¶1 Key circular economy indicators for ocean sectors include:

¶2 **Discard ratio in fisheries** – the proportion of catch that is discarded rather than landed:

> *Discard Ratio = Discarded Catch / Gross Catch*

¶3 The SEEA CF treats discarded catch as "natural resource residuals"—flows that are extracted but immediately returned to the environment [28]. SDG indicator 14.4.1 and related fisheries management frameworks track bycatch and discard reduction.

¶4 **Caveat – landing obligation jurisdictions.** In jurisdictions with mandatory landing obligations, such as EU member states operating under the Landing Obligation (EU Regulation 1380/2013, Article 15), reported discard rates may approach zero through legal mandate rather than through genuine circular economy improvement [29]. A near-zero discard ratio in such a jurisdiction does not indicate that all extracted biomass is being utilised effectively. A large share of the legally mandated landed catch may consist of fish below minimum conservation reference size (MCRS) with low or negative commercial value. Compilers in landing-obligation jurisdictions should therefore report alongside the discard ratio:

- ¶5 **(a) Proportion of landed catch below MCRS** – an indicator of bycatch management performance rather than waste reduction. Data sources and stock reference points are described in **TG-6.7 Fisheries Stock Assessment**.
- ¶6 **(b) Economic utilisation ratio** – the proportion of gross catch that is landed with positive commercial value:

> *Economic Utilisation Ratio = Commercially Utilised Landed Catch / Gross Catch*

¶7 This complementary indicator captures the economic dimension of catch utilisation that the discard ratio obscures when discard bans are in force.

¶8 **Fish waste utilisation rate** – the proportion of fish processing residues (heads, bones, offal) that are converted to useful products (fishmeal, fish oil, fertiliser):

DRAFT

> *Waste Utilisation Rate = Residues Utilised / Total Processing Residues*

¶9 **National recycling rate** — SDG indicator 12.5.1 measures the national recycling rate[30], which can be disaggregated for materials relevant to ocean sectors (plastics, metals from shipbuilding).

¶10 **Marine litter generation** — flows of waste to the marine environment, representing a failure of circular economy systems. Addressed in **TG-2.7 Pollution Flows** and **TG-6.12 Marine Litter**.

Resource recovery indicators

¶1 For extractive ocean industries, resource recovery indicators measure the proportion of in-situ resources that are successfully captured:

¶2 **Extraction efficiency for minerals** — the proportion of identified reserves that are extracted over the lifetime of an operation, relevant for seabed mining and offshore hydrocarbons.

¶3 **Energy recovery in offshore operations** — the proportion of potential energy content captured in oil and gas extraction, accounting for losses from flaring, venting, and fugitive emissions. See **TG-3.10 Offshore Energy Accounts** for detailed guidance.

3.5 Sector-Specific Efficiency Indicators

¶1 Different ocean sectors require tailored efficiency indicators that reflect their specific resource use patterns and economic characteristics.

Fisheries efficiency indicators

¶1 For the fishing industry, key efficiency indicators include:

Indicator	Formula	Policy Relevance	Cross-Reference
Economic yield per unit effort	GVA / Fishing effort (days at sea)	Fishing capacity management	**TG-6.7**
Value added per tonne caught	GVA / Catch (tonnes)	Resource productivity	**TG-3.2**
Fuel efficiency	Catch (tonnes) / Fuel consumption	Operating costs, emissions	**TG-2.8**
Employment per tonne	Employment / Catch (tonnes)	Social efficiency	**TG-3.3**

¶2 *Table 2: Key fisheries efficiency indicators. For the fallback data hierarchy (preferred gross catch vs. landings vs. bounded estimate), see Section 3.2.*

¶3 The relationship between these indicators and sustainable yield is addressed in **TG-6.7 Fisheries Stock Assessment**.

Aquaculture efficiency indicators

¶1 For aquaculture, efficiency indicators focus on feed conversion, water use, and energy intensity:

Indicator	Formula	Policy Relevance	Cross-Reference
Feed conversion ratio	Feed input (kg) / Fish output (kg)	Resource efficiency (fed species only)	**TG-3.9**
Water productivity	Output (tonnes) / Water use (m^3)	Water resource management	**TG-3.9**
Energy intensity	Energy use / Output (tonnes)	Operating costs, emissions	**TG-2.8**

DRAFT

Indicator	Formula	Policy Relevance	Cross-Reference
Land use efficiency	Output (tonnes) / Area (hectares)	Spatial planning	TG-1.2
Biofiltration ratio (filter-feeders)	Volume filtered (m^3) / Production (kg)	Water quality co-benefit	TG-3.9
Chlorophyll removal rate (filter-feeders)	Chlorophyll removed ($\mu g/L \cdot m^3$) / Production (kg)	Eutrophication management	TG-3.9
Area productivity (filter-feeders)	Production (kg) / Cultivation area (ha·yr)	Spatial planning	TG-1.2

¶2 *Table 3: Key aquaculture efficiency indicators. The feed conversion ratio applies to fed species (finfish, shrimp); it is inapplicable to filter-feeding bivalves (oysters, mussels, clams) that require no manufactured feed input. For bivalve aquaculture, use the three filter-feeder indicators listed above. For integrated multi-trophic aquaculture (IMTA) systems, efficiency should be assessed at the whole-system level: sum GVA across all trophic levels and divide by external inputs only, excluding internal nutrient cycling within the system. Detailed guidance on aquaculture system-boundary definition is provided in TG-3.9 Aquaculture Accounts.*

Maritime transport efficiency indicators

¶1 For shipping and maritime transport, efficiency indicators serve two distinct purposes that require different data sources and compilation agencies. Compilers should not attempt to combine or aggregate indicators from the two sub-tables below into a single score.

¶2 **Sub-table 4a: IMO-aligned physical efficiency indicators**

¶3 These indicators are defined by the International Maritime Organization and compiled primarily by port authorities, ship registries, and flag state administrations rather than national statistics offices. NSOs should coordinate with the relevant maritime administration to obtain these data.

DRAFT

Indicator	Formula	Policy Relevance	Cross-Reference
Energy Efficiency Operational Indicator (EEOI)	CO2 emissions / Transport work (tonne-nm)	IMO MEPC.1/Circ.684 [31]	TG-2.8
Carbon Intensity Indicator (CII)	CO2 emissions / Transport work (tonne-nm)	IMO MEPC.377(80) [32]	TG-2.8

¶4 *Table 4a: IMO-aligned physical efficiency indicators. Units are IMO standard (tonne-nautical-miles). These are regulatory compliance metrics; they do not involve monetary values and cannot be combined with the economic efficiency indicators in Table 4b.*

¶5 **Sub-table 4b: NSO-compiled economic efficiency indicators**

¶6 These indicators are compiled by national statistics offices using monetary and physical data from the national accounts and transport statistics.

Indicator	Formula	Policy Relevance	Cross-Reference
Total energy intensity	All energy (toe) / Transport output (tonne-km)	Overall energy productivity	TG-3.3
Fossil energy intensity	Fossil energy (toe) / Transport output (tonne-km)	Decarbonisation tracking	TG-2.8
Renewable energy share	Renewable energy / Total energy (%)	Fuel mix transition	TG-2.8

Indicator	Formula	Policy Relevance	Cross-Reference
Value added per tonne-km	GVA / Transport output (tonne-km)	Economic productivity	**TG-3.3**
Fleet age and efficiency	Average vessel age, average efficiency rating	Fleet modernisation	**TG-4.3**

¶7 *Table 4b: NSO-compiled economic efficiency indicators. The three energy sub-indicators (total intensity, fossil intensity, renewable share) are required for decarbonisation monitoring; total energy intensity alone is insufficient. See Section 3.2 for the rationale.*

¶8 The International Maritime Organization's greenhouse gas strategy establishes targets for reducing carbon intensity of international shipping [32].

Offshore energy efficiency indicators

¶1 For offshore energy extraction, efficiency indicators address both conventional and renewable energy:

Indicator	Formula	Policy Relevance	Cross-Reference
Energy return on investment	Energy extracted / Energy invested	Net energy contribution	**TG-3.10**
Capacity factor	Actual generation / Potential generation	Renewable energy performance	**TG-3.10**
Value added per energy unit	GVA / Energy output (joules)	Economic productivity	**TG-3.3**
Decommissioning intensity	Decommissioning waste / Energy produced	Circular economy	**TG-3.4**

¶2 *Table 5: Key offshore energy efficiency indicators*

DRAFT

3.6 Compilation Procedure

¶1 The procedure described below follows the SEEA Central Framework guidance on combined presentations and indicator derivation [33].

Step-by-step compilation

¶1 **Steps 1–3 are compilation, not indicator derivation.** The efficiency ratios below divide an economic measure by a physical one, and both come from accounts compiled elsewhere:

- ¶2 **The economic measure** — GVA by ocean industry, with ocean ratios applied — from **TG-3.3 Economic Activity Relevant to the Ocean** Sections 3.4 and 3.5. Where an enterprise straddles the ocean boundary under one ISIC code, TG-3.3 Section 3.4 sets the default allocation key (revenue share) and the requirement to hold it constant across the time series; the ISIC concordance with the allocation key and preferred data source per class is TG-3.3 Table 2.
- ¶3 **The physical measure** — fish catch, water abstraction, energy consumption by industry — from **TG-3.2 Flows from Environment to Economy** Section 3.3 for natural resource inputs, and **TG-3.4 Flows from Economy to Environment** for residuals.

¶4 **The one condition that governs whether a ratio is meaningful**: the physical and monetary accounts must use the same industry classification and the same reference period. Where they do not, reconcile through the TG-3.3 Table 2 concordance before computing anything — an efficiency ratio built across mismatched classifications is not an efficiency ratio, and the mismatch is invisible in the result. Common cases are disaggregating offshore energy from total energy extraction, and isolating the coastal tourism share of accommodation water use.

¶5 **Step 4: Compute resource efficiency ratios.** For each industry and resource type, compute the efficiency ratio:

> *Resource Efficiency = GVA (constant-price currency units) / Physical Input (physical units)*

¶6 Or the intensity ratio:

> *Resource Intensity = Physical Input (physical units) / GVA (constant-price currency units)*

¶7 For time-series resource efficiency indicators, GVA must be expressed in constant prices (volume terms) using the industry-specific output deflator, or the GDP deflator as a fallback. Expressing GVA in current prices will conflate price inflation with genuine efficiency improvement. If fish prices double whilst catch and processing methods are unchanged, current-price fish productivity doubles even though no real efficiency gain has occurred. Where only current-price GVA is available, compilers must present both the nominal (current-price) and real (constant-price) efficiency series side by side and prominently note the price basis of each. Deflation methodology follows **TG-3.3 Economic Activity** on price and volume measures. See also SEEA CF paras 6.107–6.110 [34] and SNA 2025 Chapter 15 on constant-price GDP denominators.

¶8 Document the units clearly (e.g., "constant-2020-USD per tonne of fish caught" or "joules per constant-2020-USD of shipping GVA") and the price base year.

¶9 **Step 5: Compile time series and compute growth rates.** For decoupling analysis, compile resource efficiency indicators for multiple years (minimum five years recommended). Compute annual growth rates for both economic output and physical input variables. Apply the decoupling formulas and decision tree from Section 3.3 to derive decoupling factors or elasticities, noting any years where zero or negative output growth requires the fallback procedure.

¶10 **Step 6: Present results with context.** Resource efficiency indicators should be presented alongside:

- ¶11 The absolute levels of both numerator and denominator (to avoid misleading interpretations)
- ¶12 Benchmark comparisons (national average, international comparisons, historical trends)
- ¶13 Contextual information on policy drivers, structural changes, or data quality limitations

Data quality and uncertainty

¶1 Resource efficiency indicators are ratio estimates derived from two independently compiled datasets — monetary accounts and physical flow accounts — each with its own measurement error. Compilers should assess and communicate data quality using the following framework.

¶2 **Uncertainty propagation.** The relative standard error (RSE) of a ratio indicator is approximately the root-sum-of-squares of the relative standard errors of the numerator and denominator:

> $RSE(ratio) \approx \sqrt{(RSE_{numerator}^2 + RSE_{denominator}^2)}$

¶3 For example, if the GVA estimate has a relative standard error of 5% and the physical catch estimate has a relative standard error of 8%, the fish productivity ratio has an approximate relative standard error of $\sqrt{(25 + 64)} = \sqrt{89} \approx 9.4\%$.

¶4 **Three-tier quality classification.** Compilers should assign each published resource efficiency indicator to one of three quality tiers:

DRAFT

Tier	Label	Criteria	Presentation requirement
1	Indicative	Single source; no independent uncertainty estimate available	Flag as "indicative" in table notes; do not cite in official statistical releases without review
2	Intermediate	Two independent sources; approximate error range can be constructed	Publish with an approximate range (e.g., ±X%) derived from the RSE formula above
3	Published	Two independent sources; formal standard error computed; revision policy documented	Publish with formal confidence interval; include in official national statistical releases

¶5 **Methodological note requirement.** Any official publication of resource efficiency indicators must include a methodological note describing: (1) the data sources used for numerator and denominator, (2) the price basis and deflator applied, (3) the industry classification concordance method, (4) the revision policy, and (5) known limitations (e.g., substitution of landings for gross catch, or use of current-price GVA for recent years pending deflator availability). This requirement aligns with the UN Fundamental Principles of Official Statistics [35] and the PARIS21 data quality assessment framework [36].

3.7 Worked Examples

¶1 This section presents worked examples illustrating the compilation and interpretation of resource efficiency indicators for a hypothetical medium-income coastal state ("Country B"). All monetary values are expressed in constant 2020 USD unless otherwise noted. Physical quantities use standard SI units.

Example 1: Marine fishing material productivity

¶1 **Context:** Country B's marine fishing industry reported the following data for 2023 and 2024 (GVA in constant 2020 USD):

Year	Gross catch (tonnes)	Fishing industry GVA (million USD, constant 2020)	Discarded catch (tonnes)	Data availability
2023	120,000	180	24,000	Gross catch: observer programme; GVA: supply and use tables
2024	115,000	190	20,000	Gross catch: observer programme; GVA: supply and use tables

¶2 **Computation:**

¶3 Fish productivity (2023):

> *USD 180,000,000 / 120,000 tonnes = USD 1,500/tonne*

¶4 Fish productivity (2024):

> *USD 190,000,000 / 115,000 tonnes = USD 1,652/tonne*

¶5 Productivity change:

DRAFT

> *(1,652 - 1,500) / 1,500 × 100 = 10.1% increase*

¶6 Discard ratio (2023):

> *24,000 / 120,000 = 20%*

¶7 Discard ratio (2024):

> *20,000 / 115,000 = 17.4%*

¶8 **Interpretation:** Fish productivity increased by 10.1 per cent between 2023 and 2024, whilst total catch declined by 4.2 per cent. This suggests improved economic efficiency: the industry generated more value per tonne of fish extracted. The declining discard ratio (from 20 per cent to 17.4 per cent) indicates progress toward circular economy principles, with a larger proportion of catch being landed rather than discarded. However, compilers should verify whether the productivity increase reflects sustainable management (higher-value species, better processing) or scarcity effects (rising prices for depleted stocks). Cross-referencing with stock assessment data from **TG-6.7** would provide this context. A practical diagnostic: if fish productivity (USD per tonne) is rising whilst catch per unit effort (CPUE) is declining and stock biomass is below B_MSY, the productivity increase likely reflects scarcity-driven price inflation rather than genuine efficiency improvement.

Example 2: Aquaculture water productivity

¶1 **Context:** Country B's marine aquaculture industry operates primarily extensive flow-through pond systems for shrimp and finfish production. GVA is expressed in constant 2020 USD.

Year	Production (tonnes)	GVA (million USD, constant 2020)	Water abstraction (million m³)	System type
2023	45,000	135	9	Flow-through ponds
2024	48,000	145	9.2	Flow-through ponds

¶2 Note: water abstraction for flow-through pond systems (9 million m³ = 9,000,000 m³ in 2023) is used as the denominator in accordance with the system-type formula table in Section 3.2. Water use per tonne of production (2023) = 9,000,000 m³ / 45,000 tonnes = 200 m³/tonne, consistent with FAO benchmark ranges of 100–500 m³/tonne for semi-intensive tropical shrimp pond systems [37].

¶3 **Computation:**

¶4 Water productivity (2023):

> *USD 135,000,000 / 9,000,000 m³ = USD 15.00/m³*

¶5 Water productivity (2024):

> *USD 145,000,000 / 9,200,000 m³ = USD 15.76/m³*

DRAFT

¶6 Productivity change:

> *(15.76 - 15.00) / 15.00 × 100 = 5.1% increase*

¶7 Output per water unit (2023):

> *45,000 tonnes / 9,000,000 m³ = 5.0 kg/m³*

¶8 Output per water unit (2024):

> *48,000 tonnes / 9,200,000 m³ = 5.2 kg/m³*

¶9 **Plausibility check:** FAO benchmark water use intensities for semi-intensive tropical pond aquaculture range from approximately 100 to 500 m³/tonne depending on exchange rate and climate [37]. Country B's 200 m³/tonne falls within this range. If a compiler's calculated value falls outside 100–2,000 m³/tonne for any pond system, the input data should be reviewed before publication.

¶10 **Interpretation:** Aquaculture water productivity improved by 5.1 per cent, indicating that the industry generated more economic value per cubic metre of water abstracted. Physical output per water unit also increased slightly (from 5.0 to 5.2 kg/m³), suggesting genuine improvements in water use efficiency rather than price effects alone. This progress aligns with SDG Target 12.2 on efficient use of natural resources. The modest increase in total water abstraction (2.2 per cent) coupled with a 6.7 per cent increase in production demonstrates relative decoupling of aquaculture growth from water abstraction.

Example 3: Maritime transport energy intensity and decoupling

¶1 **Context:** Country B's maritime transport sector (sea and coastal freight and passenger transport) reported (GVA in constant 2020 USD):

Year	GVA (million USD, constant 2020)	Fuel consumption (thousand toe)	Transport output (billion tonne-km)
2019	420	850	145
2020	385	790	130
2021	410	800	138
2022	440	820	148
2023	465	830	155
2024	490	840	162

¶2 Note: 2020 is flagged as a structural break year due to the COVID-19 pandemic (see Section 3.3). The 2020 structural break triggers the sub-period pathway in the Section 3.3 decision tree. Apply that pathway as specified.

¶3 **Computation — full period (2019–2024):**

¶4 The indicators computed below are NSO-compiled economic efficiency indicators (Sub-table 4b). The IMO-defined physical indicators in Sub-table 4a require separate data and compilation procedures not illustrated here.

¶5 Energy intensity (2024):

DRAFT

> *840,000 toe / USD 490,000,000 = 1,714 toe per million USD GVA*

¶6 Or per physical output:

> *840,000 toe / 162,000,000,000 tonne-km = 5.19 toe per million tonne-km*

¶7 Energy intensity (2019):

> *850,000 toe / 145,000,000,000 tonne-km = 5.86 toe per million tonne-km*

¶8 Five-year GVA growth (2019-2024):

> *(490 - 420) / 420 × 100 = 16.7%*

¶9 Five-year energy consumption growth:

> *(840 - 850) / 850 × 100 = -1.2%*

¶10 No single decoupling factor is computed for 2019–2024, because the period spans the 2020 break (Section 3.3). The factor is computed within the post-break sub-period; the pre-break side holds only 2019.

¶11 **Post-break sub-period (2021–2024):**

¶12 GVA growth (2021-2024):

> *(490 - 410) / 410 × 100 = 19.5%*

¶13 Energy consumption growth (2021-2024):

> *(840 - 800) / 800 × 100 = 5.0%*

¶14 Decoupling factor:

> *1 - (5.0% / 19.5%) = 0.74*

¶15 **Structural break sub-period (2019–2020):** Index numbers (base 2019 = 100): GVA = 91.7, energy = 92.9.

¶16 **Interpretation:** Country B's maritime transport sector achieved relative decoupling in the post-break period 2021–2024: GVA grew by 19.5 per cent whilst energy consumption grew by 5.0 per cent, a decoupling factor of 0.74 (between 0 and 1). Over 2019–2024 GVA grew by 16.7 per cent and energy consumption fell by 1.2 per cent, but no single factor is reported across the 2020 break. The energy intensity per tonne-km declined from 5.86 toe/million tonne-km in 2019 to 5.19 in 2024 (11.4 per cent improvement), demonstrating genuine efficiency gains. The temporary dip in

DRAFT

2020 (COVID-19 pandemic) has been flagged as a structural break. The sub-period analysis confirms that the 2019–2020 contraction does not by itself indicate efficiency improvement. This performance contributes to national progress under SDG Target 8.4 and aligns with the IMO's greenhouse gas reduction strategy.

¶17 ⓘ **Corrected 24 September 2026**

¶18 This example previously reported a single 2019–2024 decoupling factor of 1.07 (absolute decoupling), which spans the 2020 structural break that Section 3.3 says must split the series. Computed within the post-break sub-period, the factor is 0.74: relative, not absolute, decoupling.

Example 4: Ocean economy-wide decoupling analysis

¶1 **Context:** Country B's total ocean economy reported the following aggregates over a ten-year period (GVA in constant 2020 USD). Per the base-year selection guidance in Section 3.3, the base year (2014) was selected as the year prior to Country B's adoption of its first national ocean economy development plan. The comparison points use evenly spaced five-year intervals.

Year	Ocean GVA (million USD, constant 2020)	Fish catch (tonnes)	Energy use (thousand toe)	Water abstraction (million m³)
2014	1,380	138,000	2,050	1,750
2019	1,720	128,000	2,250	1,950
2024	1,950	125,000	2,300	2,050

¶2 Note: 2019 and 2024 are the two five-year endpoints. The year 2020 has been excluded as a structural break year (COVID-19). It must not be used as a base year or comparison endpoint. Base-year sensitivity testing follows the procedure in Section 3.3. Alternative base years (2013 and 2015) yielded decoupling factors for fish extraction ranging from 1.18 to 1.24.

¶3 **Computation — period 1 (2014–2019):**

¶4 GVA growth: (1,720 - 1,380) / 1,380 × 100 = 24.6%

- ¶5 Fish catch: (128,000 - 138,000) / 138,000 × 100 = -7.2% → Decoupling factor: 1 - (-7.2% / 24.6%) = 1.29 (absolute decoupling)
- ¶6 Energy use: (2,250 - 2,050) / 2,050 × 100 = 9.8% → Decoupling factor: 1 - (9.8% / 24.6%) = 0.60 (relative decoupling)
- ¶7 Water abstraction: (1,950 - 1,750) / 1,750 × 100 = 11.4% → Decoupling factor: 1 - (11.4% / 24.6%) = 0.54 (relative decoupling)

¶8 **Computation — period 2 (2019–2024):**

¶9 GVA growth: (1,950 - 1,720) / 1,720 × 100 = 13.4%

- ¶10 Fish catch: (125,000 - 128,000) / 128,000 × 100 = -2.3% → Decoupling factor: 1 - (-2.3% / 13.4%) = 1.17 (absolute decoupling)
- ¶11 Energy use: (2,300 - 2,250) / 2,250 × 100 = 2.2% → Decoupling factor: 1 - (2.2% / 13.4%) = 0.84 (relative decoupling)
- ¶12 Water abstraction: (2,050 - 1,950) / 1,950 × 100 = 5.1% → Decoupling factor: 1 - (5.1% / 13.4%) = 0.62 (relative decoupling)

¶13 **Interpretation:** Across both sub-periods, Country B's ocean economy decoupled absolutely from fish extraction and relatively from energy and water use. Absolute decoupling of fish extraction was stronger in the first period (factor 1.29) than the second (1.17), which may indicate that the easiest efficiency gains have been captured and further progress requires additional policy effort. Relative decoupling improved for energy use between the two periods (factor rising from 0.60 to 0.84), suggesting that energy productivity gains are slowing and the sector is approaching the limits of operational efficiency improvements without technology transition. Water abstraction

DRAFT

exhibits consistent relative decoupling across both periods (0.54 and 0.62), with room for further improvement. These results can be reported under SDG indicators 8.4.1 and 12.2.1.

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

5. References

1. ¶1 SEEA Central Framework, para 1.20. "Topics covered include resource efficiency and productivity indicators, decomposition analysis, analysis of net wealth and depletion, sustainable production and consumption."
2. ¶2 SEEA Central Framework, para 1.20 identifies the *SEEA Applications and Extensions* publication as providing extended guidance on resource efficiency and productivity indicators, decomposition analysis, and related topics.
3. ¶3 SEEA Energy, Chapter 7 on indicators and Chapter 4 on combined presentations; SEEA Energy para 4.53 on deriving energy-related indicators.
4. ¶4 SEEA-Water, Chapter 9 on indicators and policy applications; SEEA-Water Annex 3, Tables A3.1–A3.2 on water intensity and productivity indicators.
5. ¶5 SEEA Central Framework, para 1.54. Combined presentations "structure information in a manner that supports the derivation of combined indicators, for example, decoupling indicators."
6. ¶6 European Commission (2020). *A new Circular Economy Action Plan: For a cleaner and more competitive Europe*. Brussels. COM(2020) 98 final.
7. ¶7 United Nations General Assembly (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*. A/RES/70/1. SDG Target 8.4.
8. ¶8 United Nations General Assembly (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*. A/RES/70/1. SDG Target 12.2.
9. ¶9 United Nations (2024). *Global indicator framework for the Sustainable Development Goals*. SDG indicators 8.4.1, 8.4.2, 12.2.1, and 12.2.2 on material footprint and domestic material consumption.
0. ¶10 OECD (2011). *Towards Green Growth*. Paris: OECD Publishing. Identifies resource productivity as a key indicator of progress toward green growth.
1. ¶11 SEEA Energy, para 4.53. "Combined presentations are also useful for the derivation of many energy-related indicators."
2. ¶12 Adapted from SEEA Applications and Extensions framework for resource efficiency indicators.
3. ¶13 SEEA Energy, Section 7.5.1 on energy intensities for selected industries; SEEA Energy Table 4.6 on calculating energy intensity of industries.
4. ¶14 SEEA Central Framework, paras 5.428–5.429. The SEEA CF recommends using gross catch rather than landings as the measure of extraction.
5. ¶15 United Nations (2024). *Global indicator framework*. SDG indicator 14.4.1: "Proportion of fish stocks within biologically sustainable levels."
6. ¶16 SEEA-Water, Annex 3, Tables A3.1–A3.2 on water intensity and productivity indicators.
7. ¶17 SEEA-Water, Annex 3, Table A3.2. Provides the methodology for calculating water consumption (abstraction minus return flows) for different water use categories, including aquaculture systems.
8. ¶18 SEEA-Water, paras 1.24–1.25. Water efficiency "can be improved from the demand as well as the supply side."
9. ¶19 SEEA Energy, Chapter 7 on energy indicators linked to social, economic, and environmental dimensions.
0. ¶20 SEEA Energy, Chapter 4 on energy supply and use tables, including fuel-type classification. Distinguishes petroleum products, natural gas, electricity, biofuels, and other renewable energy sources.
1. ¶21 SEEA Energy, Table 7.2. Energy use per unit of GDP is identified as an overall productivity indicator.
2. ¶22 SEEA Central Framework, para 1.54.
3. ¶23 SDG Target 8.4. "Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation."
4. ¶24 OECD (2002). *Indicators to Measure Decoupling of Environmental Pressure from Economic Growth*. Paris: OECD Publishing.
5. ¶25 United Nations (2024). *Global indicator framework*. SDG indicators 8.4.1 and 12.2.1 on material footprint per GDP.
6. ¶26 SDG Target 12.5. "By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse."
7. ¶27 Ellen MacArthur Foundation (2015). *Towards a Circular Economy: Business Rationale for an Accelerated Transition*. The circular economy framework emphasises keeping materials in use and regenerating natural systems.
8. ¶28 SEEA Central Framework, para 3.50 on unused extraction including discarded catch; FAO (1995) *Code of Conduct for Responsible Fisheries* on bycatch and discard reduction.

DRAFT

9. ¶29 EU Regulation 1380/2013 (Common Fisheries Policy), Article 15 (Landing Obligation). Phased in progressively from January 2015 and fully applicable from January 2019. Requires EU fishers to land almost all caught species, with specific exemptions for prohibited species, high-survival species, and de minimis quantities.
0. ¶30 United Nations (2024). *Global indicator framework*. SDG indicator 12.5.1: "National recycling rate, tons of material recycled."
1. ¶31 International Maritime Organization (2009). *Guidelines for Voluntary Use of the Ship Energy Efficiency Operational Indicator (EEOI)*. MEPC.1/Circ.684. Issued August 2009. Defines the EEOI as mass of CO2 emitted divided by transport work in tonne-nautical-miles.
2. ¶32 International Maritime Organization (2023). *2023 IMO Strategy on Reduction of GHG Emissions from Ships* (MEPC.377(80)). Targets include reducing total annual GHG emissions from international shipping by at least 20% by 2030 (striving for 30%) and by at least 70% by 2040 (striving for 80%) compared to 2008, with a commitment to reaching net-zero GHG emissions by or around 2050.
3. ¶33 SEEA Central Framework, paras 6.107–6.110 on productivity, intensity, and decoupling indicators; SEEA Energy Table 4.6 and para 4.53 on combined presentations for indicator derivation.
4. ¶34 SEEA Central Framework, Chapter 6, Section 6.4 on combined presentations; SEEA CF paras 6.107–6.110 on productivity, intensity, and decoupling indicators.
5. ¶35 United Nations Statistical Commission (1994, reaffirmed 2013). *Fundamental Principles of Official Statistics*. Principle 3 on accountability and transparency; Principle 6 on data quality and confidentiality.
6. ¶36 PARIS21 (2021). *Data Quality Assessment Framework*. Describes minimum quality standards for national statistical indicators, including uncertainty reporting and methodological documentation.
7. ¶37 FAO (2014). *Small-scale aquaculture technical guidance: water use benchmarks*. Typical water use intensities for semi-intensive tropical pond aquaculture range from approximately 100 to 500 m³ per tonne of production depending on exchange rate, climate, and management practice. See also Verdegem, M.C.J. and Bosma, R.H. (2009). Water withdrawal for brackish and inland aquaculture, and options to produce more fish in ponds with present water use. *Water Policy* 11(S1): 52–68.

DRAFT

Spatial Data Frameworks

Helps compilers establish the spatial data foundations required for ocean accounting.

Version 0.10.1 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

OUTCOME

After reading this Circular, compilers will be able to establish the spatial data foundations required for ocean accounting. The guidance covers five interconnected framework dimensions: (1) selecting and documenting coordinate reference systems and map projections, (2) defining ocean boundaries for the ecosystem accounting area, (3) setting minimum mapping units appropriate to ecosystem type and data source, and the Basic Spatial Unit resolution that follows from them, (4) ensuring temporal consistency across spatial data vintages, and (5) quantifying and reporting spatial uncertainty according to recognised metadata standards.

Section 3.3 is normative for the publication on spatial resolution. It sets minimum mapping units by ecosystem type and data source, relates them to BSU side length, and gives indicative BSU resolutions by marine context. Circulars that use spatially explicit accounts refer to it rather than specifying their own resolution, and the question a planning, assessment or management process asks is whether the resolution of the available accounts is adequate to the decision at hand.

Spatial data frameworks determine the comparability, consistency, and interpretability of all spatially explicit ocean accounts, and cannot be deferred once compilation begins. Decisions made at the framework design stage propagate through the entire accounting system, affecting ecosystem extent accounts (TG-3.1 Asset Accounts), ecosystem service flow accounts (TG-3.2 Flows from Environment to Economy), and all Section 6 thematic accounts.

The Circular does not address ecological modelling methods used to estimate ecosystem services — those are addressed in the relevant thematic circulars. It also does not duplicate the remote sensing data acquisition guidance in TG-4.1 Remote Sensing and Geospatial Data. Instead, it addresses the spatial framework that governs how remotely sensed and other geospatial data are organised, projected, and documented before they enter the accounting system.

DRAFT

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 4
3.1 Coordinate Reference Systems and Projections 4
3.2 Ocean Boundary Definitions 6
3.3 Minimum Mapping Units 8
3.4 Temporal Consistency of Spatial Layers 12
3.5 Spatial Uncertainty and Metadata Standards 14
3.6 Worked Example: Spatial Framework for a Mangrove-Seagrass Complex 16
4. Acknowledgements 18
5. References 18

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Spatial Data Frameworks (2026) (GOAP Technical Guidance on Ocean Accounting, TG-2.12, v0.10.1). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-2/2-12-spatial-data-frameworks/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

¶1 **Framework Position**

¶2 TG-2.12 establishes the spatial data foundations that all ocean accounts depend on: coordinate reference systems, boundary definitions, minimum mapping units, temporal consistency rules, and uncertainty reporting standards. **This is a data-methods circular, not an indicator circular.** It sits between the data acquisition guidance in **TG-4.1 Remote Sensing and Geospatial Data** and the account compilation circulars in Sections 3 and 6 that consume spatial extent data, and on the scope test in **TG-0.4** §3.1 it belongs in Section 4. It is numbered in Section 2 for historical reasons and will be renumbered at the Second Edition; renumbering it during the consultation would orphan comments already filed against TG-2.12. Section 3.3 is normative for minimum mapping units and Basic Spatial Unit resolution across the publication.

1. Outcome

¶1 After reading this Circular, compilers will be able to establish the spatial data foundations required for ocean accounting. The guidance covers five interconnected framework dimensions: (1) selecting and documenting coordinate reference systems and map projections, (2) defining ocean boundaries for the ecosystem accounting area, (3) setting minimum mapping units appropriate to ecosystem type and data source, and the Basic Spatial Unit resolution that follows from them, (4) ensuring temporal consistency across spatial data vintages, and (5) quantifying and reporting spatial uncertainty according to recognised metadata standards.

¶2 **Section 3.3 is normative for the publication on spatial resolution.** It sets minimum mapping units by ecosystem type and data source, relates them to BSU side length, and gives indicative BSU resolutions by marine context. Circulars that use spatially explicit accounts refer to it rather than specifying their own resolution, and the question a planning, assessment or management process asks is whether the resolution of the available accounts is adequate to the decision at hand.

¶3 Spatial data frameworks determine the comparability, consistency, and interpretability of all spatially explicit ocean accounts, and cannot be deferred once compilation begins. Decisions made at the framework design stage propagate through the entire accounting system, affecting ecosystem extent accounts (**TG-3.1 Asset Accounts**), ecosystem service flow accounts (**TG-3.2 Flows from Environment to Economy**), and all Section 6 thematic accounts.

¶4 The Circular does not address ecological modelling methods used to estimate ecosystem services — those are addressed in the relevant thematic circulars. It also does not duplicate the remote sensing data acquisition guidance in **TG-4.1 Remote Sensing and Geospatial Data**. Instead, it addresses the spatial framework that governs how remotely sensed and other geospatial data are organised, projected, and documented before they enter the accounting system.

2. Requirements

- ¶1 **TG-0.1 General Introduction to Ocean Accounts** — foundational framework, including the concept of ecosystem accounting areas and the scope of ocean accounts
- ¶2 **TG-0.2 Overview of Relevant Statistical Standards** — classification and measurement standards referenced throughout this Circular, including SEEA EA spatial unit definitions
- ¶3 **TG-0.7 Quality Assurance Principles** — QA requirements for spatial datasets, including documentation, reproducibility, and fitness-for-purpose assessment
- ¶4 **TG-4.1 Remote Sensing and Geospatial Data** — primary spatial data source for ocean ecosystem extent mapping, and this Circular governs how those data are projected, bounded, and documented

¶5 **Helpful background:**

- ¶6 **TG-3.1 Asset Accounts** — the principal consumer of spatial extent data, and framework decisions in TG-2.12 directly affect what can be compiled in TG-3.1

DRAFT

- ¶7 **TG-2.1 Aggregate Biophysical Indicators of Environmental State** — biophysical indicators that draw on spatially explicit extent and condition data

3. Guidance Material

3.1 Coordinate Reference Systems and Projections

3.1.1 The role of coordinate reference systems in ocean accounting

¶1 A **coordinate reference system (CRS)** is the mathematical framework that relates spatial measurements — positions, areas, distances — to locations on the Earth's surface. For ocean accounting, CRS selection affects two distinct operations: data storage and exchange (which requires geographic consistency across data sources from different agencies and countries) and area-based accounting calculations (which require area-preserving properties that geographic CRS do not provide).

¶2 SEEA EA para. 3.89 notes that a Basic Spatial Unit (BSU)-based structure enables integration of spatial data "on different characteristics and hence account for varying spatial coverage, scales and projections."[1], [1] The BSU structure therefore requires compilers to select a single, documented CRS within which all BSU-level data are harmonised before they are assigned to ecosystem assets and accumulated into accounts.

¶3 Ocean accounts face CRS challenges that are less common in terrestrial accounting. EEZs may span the International Date Line, as in the case of many Pacific SIDS, and the projection chosen must avoid the resulting data discontinuities. Maritime zones are legally defined in geodetic terms, as nautical miles from baselines, not in projected coordinates. Global and regional data products used as inputs may also arrive in different CRS that must be transformed before integration.

3.1.2 Decision rule for CRS selection

¶1 To address both requirements simultaneously, this Circular recommends a two-tier CRS approach: one tier for data storage and exchange (prioritising interoperability), and one tier for area-based calculations (prioritising geometric accuracy). Figure 2.12.1 illustrates this two-tier workflow: data stored and exchanged under WGS84 are reprojected to an equal-area projection only when extent, area, or condition calculations are performed. An ISO 19115 metadata record documents the CRS and travels with the data into the account row.

DRAFT

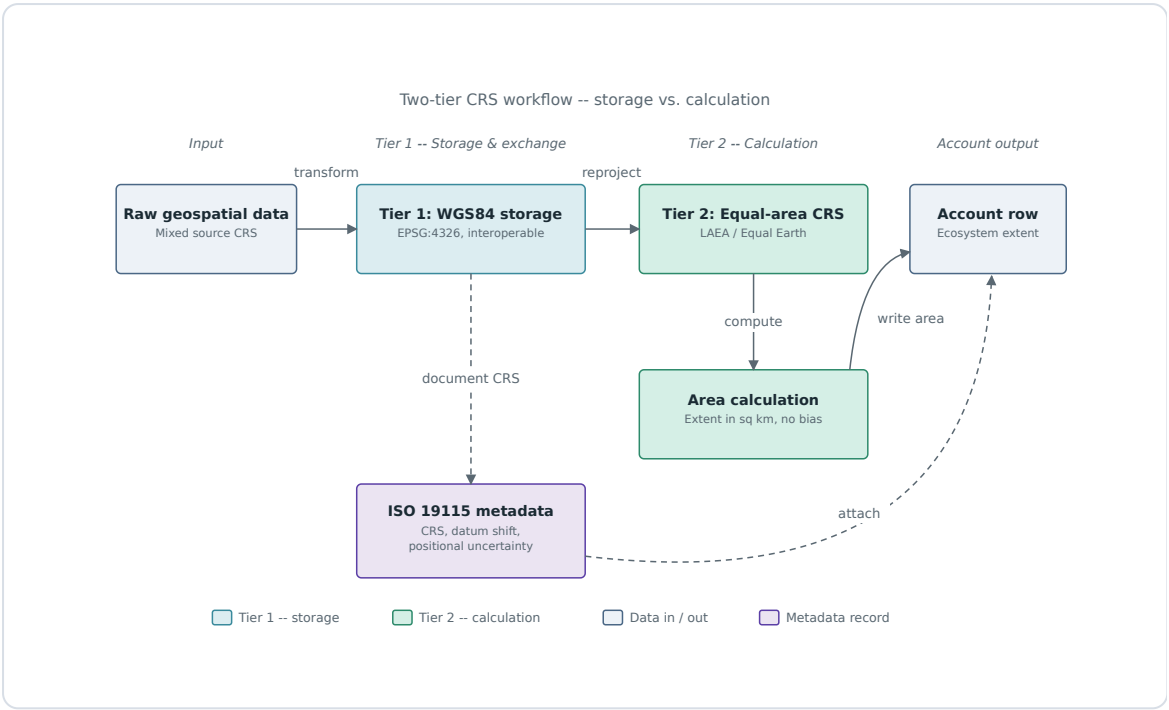


Figure 2.12.1 A two-tier CRS workflow stores data in WGS84 and reprojects to equal-area only for area calculations. Tier 1 = EPSG:4326; Tier 2 = equal-area (e.g. EPSG:8857). ISO 19115 metadata travels with each dataset.

Source: TG-2.12 Spatial Data Frameworks, §3.1.2 (two-tier CRS approach), §3.1.3 (CRS documentation) and §3.5 (ISO 19115 metadata).

Adapted from: ISO 19115-1:2014 (geographic information -- metadata); EPSG geodetic parameter registry (EPSG:4326 WGS84, EPSG:8857 Equal Earth); OGC standards for spatial data interoperability.

¶2 **Tier 1 — Storage and exchange CRS:** Use the World Geodetic System 1984 (WGS84, EPSG:4326) as the reference datum for all spatial data storage and inter-agency data exchange. WGS84 is the global standard for geospatial data interoperability and is used by GPS, most satellite remote sensing products, and the maritime boundary datasets operated by the Flanders Marine Institute (VLIZ) Maritime Boundaries Geodatabase. Data received from agencies in other CRS must be transformed to WGS84 before ingestion into the accounting data system.

¶3 **Tier 2 — Calculation CRS:** Use a national or regional equal-area projection for all area-based accounting calculations (measurement of ecosystem extent, change detection, and service flow allocation). Equal-area projections preserve area relationships across the mapped surface, ensuring that the sum of ecosystem asset areas equals the total ecosystem accounting area without systematic bias. Appropriate choices include:

- ¶4 For national-scale accounts: the national equal-area projection adopted by the country's national mapping agency (if available and documented)
- ¶5 For regional and comparative accounts: the Lambert Azimuthal Equal Area (LAEA) projection centred on the study area (EPSG codes vary by centre point)
- ¶6 For Pacific SIDS and other dateline-crossing EEZs: the Equal Earth projection (EPSG:8857) or a custom Mollweide projection centred to avoid the antimeridian discontinuity

¶7 Before adopting EPSG:8857, compilers should confirm that it is available in their GIS software. Older ESRI ArcGIS releases (pre-10.7) and QGIS versions prior to 3.16 do not include EPSG:8857 in their bundled CRS catalogues and require manual WKT entry. If EPSG:8857 is unavailable, a custom Mollweide projection centred on the study area (example PROJ string: `+proj=moll +lon_0=160 +x_0=0 +y_0=0 +datum=WGS84 +units=m` for Pacific-centred accounts) provides an equivalent equal-area property. The WKT definition used must be recorded in spatial metadata.

DRAFT

¶8 All area statistics reported in ocean accounts must be calculated in the Tier 2 CRS. Results should be reported in square kilometres rounded to appropriate precision for the ecosystem type and scale of the account.

3.1.3 Documentation requirements

¶1 The CRS used for storage, transformation, and area calculation must be documented in the spatial metadata for each dataset (see Section 3.5). The metadata record must include: (a) the EPSG code or Well-Known Text (WKT) definition of the CRS, (b) the datum transformation rule applied where data were converted between CRS, and (c) any epoch qualification if GPS-era coordinates are used. Consistent CRS documentation is essential for reproducibility and for future compilation cycles.

¶2 Many national datasets predate WGS84 and are held in local geodetic datums whose transformation parameters may be unpublished or of uncertain quality. Before applying a generic three-parameter Helmert shift, compilers should obtain the country-specific transformation parameters published by the national geodetic authority, for example through the national mapping agency or the national EPSG registry entry for the local datum. Where available, a seven-parameter Helmert transformation or a national grid-based shift file provides greater accuracy than a three-parameter shift. Grid-based shift files are most commonly distributed in NTv2 format (.gsb), although NTv2 is not universally supported: the modern PROJ datum grid format (.tif, as distributed via the PROJ CDN and PROJ-data package) is the recommended alternative where NTv2 files are unavailable or not accepted by the compiler's GIS environment. The transformation method and the estimated residual positional error after transformation must be documented in the spatial metadata. Where datum transformation uncertainty exceeds the minimum mapping unit — meaning the spatial offset could systematically misplace feature boundaries by more than one mapping unit — the affected datasets should be flagged in the metadata and in the account quality disclosure as requiring geodetic verification before final publication.

3.1.4 Scope note on vertical and 3D frameworks

¶1 Ocean ecosystems are inherently three-dimensional. SEEA EA paras. 3.9 and 3.11 acknowledge that ecosystem assets are "conceptually envisaged as three-dimensional spaces" and that marine ecosystems "extend throughout the water column and include the underlying sediment and seabed."[1] However, SEEA EA para. 3.12 recommends that, for most accounting purposes, "ecosystem assets be delineated based on the areas of the different ecosystem types associated with the seabed" — that is, a two-dimensional surface representation — because delineating in a "vertically stratified manner" is practically difficult. This Circular follows the SEEA EA recommendation: ocean accounts are compiled in two dimensions (horizontal extent) as the primary accounting pathway. Depth stratification (water-column depth zones, benthic substrate layers) is relevant to thematic circulars — particularly **TG-6.5 Pelagic and Open Ocean Accounting** and **TG-6.6 Deep Sea and ABNJ Accounting** — and should be documented in spatial metadata as an attribute rather than encoded as a third spatial dimension.

3.2 Ocean Boundary Definitions

3.2.1 Defining the ecosystem accounting area for ocean accounts

¶1 The **ecosystem accounting area (EAA)** is "the geographical territory for which an ecosystem account is compiled" (SEEA EA para. 3.22).[1] For ocean accounts, the outer boundary of the EAA is normally the outer limit of the exclusive economic zone (EEZ), which extends up to 200 nautical miles from baselines under the United Nations Convention on the Law of the Sea (UNCLOS) Parts V and VI.[2] SEEA EA para. 3.27 confirms: "the scope of national jurisdictions for ecosystem accounting should include all ecosystems across the terrestrial, freshwater and marine realms to the boundary of the exclusive economic zone."[1]

DRAFT

¶2 The EAA must be unambiguous, documented, and consistent across compilation cycles. Any change in the EAA boundary between vintages — for example, if a country ratifies a maritime boundary agreement — constitutes a change in accounting scope and must be disclosed in the compilation notes.

3.2.2 Maritime zone definitions

¶1 The following maritime zone definitions, drawn from UNCLOS, govern the outer limits of the ocean accounts EAA and its sub-zones:

Zone	Outer limit	UNCLOS reference	Accounting relevance
Internal waters	Landward of the baseline	Part II, Article 8	Included in national EAA; governed as inland waters
Territorial sea	12 nm from baseline	Part II, Article 3	Full national jurisdiction; all ecosystem types accounted
Contiguous zone	24 nm from baseline	Part II, Article 33	Limited jurisdictional relevance; ecosystem data may be sparse
Exclusive Economic Zone	Up to 200 nm from baseline	Part V, Article 57	Standard outer limit of the ocean accounts EAA
Continental shelf	Outer edge of continental margin; may extend up to 350 nm from baselines under a CLCS submission (Article 76, paras. 4–5)	Part VI, Article 76	Relevant for seabed ecosystem accounts where shelf exceeds EEZ; seabed ecosystem accounts in the area covered by an active or pending CLCS submission should be flagged as subject to boundary revision; provisional delineation should use the foot-of-the-slope formula (Article 76, para. 4)[3]

¶2 Where maritime boundaries are subject to overlapping claims or bilateral disputes, compilers should document the boundary assumptions applied and flag the relevant zones in the compilation notes. Where feasible, any disputed area should be separately tabulated to maintain transparency. The VLIZ Maritime Boundaries Geodatabase provides unilateral and bilateral boundary layers (specifically the "EEZ Boundaries" and "Maritime Boundaries" layer products available at marineregions.org). Compilers should document which VLIZ boundary layer was selected as the operational source and note any divergence between the VLIZ boundary and the national claim in the compilation notes.

¶3 Where an ecosystem asset straddles the EEZ boundaries of two or more countries without any jurisdictional dispute, each country accounts for the portion of the ecosystem asset lying within its own EEZ. Where a bilateral or regional agreement specifies a different allocation method — for example, a jointly managed marine protected area with an agreed proportional attribution of ecosystem extent — that method takes precedence and must be documented in the compilation notes. For joint accounts compiled under a regional framework (such as a SIDS regional ocean accounts programme), the shared boundary and the agreed allocation rule must be specified in the spatial framework design document and applied consistently across all participating countries. This transboundary allocation guidance applies to the undisputed case. Guidance for overlapping claims is provided in the preceding paragraph.

¶4 For SIDS and other countries with large EEZs relative to land area, the EEZ may include deep-water ecosystems for which data are limited. In these cases, compilers may initially scope accounts to cover ecosystems within the territorial sea or to the edge of the continental shelf, with a clear statement of scope limitation and a plan to extend coverage as data improve.

3.2.3 The coastal zone landward boundary

¶1 The ocean accounts EAA also requires a landward boundary where marine ecosystems transition to terrestrial ecosystems. The **coastal zone** is the transitional area between marine and terrestrial ecosystems, bounded seaward by the outer limit of the EEZ and landward by a compiler-specified boundary — typically mean high water datum, a fixed elevation contour, or an administrative boundary — that must be documented and applied consistently across compilation cycles. This landward boundary is not defined by UNCLOS and must be specified by the compiler based on the ecosystem types to be included. Table 3.2.3 below summarises common landward boundary definitions.

¶2 **Table 3.2.3: Common landward boundary definitions for the coastal zone**

Boundary Type	Description
Tidal datum	Mean high water (MHW) or mean higher high water (MHHW) — defines the seaward limit of the terrestrial EAA and the landward limit of the ocean EAA for intertidal ecosystems such as mangroves and salt marshes.
Elevation contour	A fixed elevation above mean sea level (commonly 5 m or 10 m) used as a proxy for flood-zone exposure in disaster risk applications.
Administrative boundary	A coastal district, municipality, or watershed boundary used when administrative alignment is required.

¶3 For consistency with terrestrial national accounts and land-cover data, the landward boundary should align with the boundary used by the national mapping agency for coastal zone delineation. Where no national standard exists, the compiler should adopt the MHW datum, document the choice, and apply it consistently across compilation cycles. The operational boundary layer should be derived from the VLIZ Maritime Boundaries Geodatabase (https://www.marineregions.org/ (https://www.marineregions.org/)) [4] for the EEZ outer limit and from national hydrographic or mapping agency data for the baseline and coastal zone boundary.

¶4 Intertidal ecosystem assets that straddle the MHW datum — including mangroves, salt marshes, intertidal seagrass beds, and rocky intertidal habitats — should be assigned in full to the ocean EAA (i.e., the marine side of the boundary), consistent with SEEA EA ecosystem asset definitions that treat the seaward-extending ecosystem unit as the defining asset. Where national accounts or prior assessments have applied a different intertidal assignment convention (for example, assigning mangroves to the terrestrial EAA for consistency with national land-cover datasets), the convention applied and any departure from the default must be documented in the compilation notes and disclosed in the account metadata so that users can assess cross-country comparability.

DRAFT

3.2.4 Accounting for areas beyond national jurisdiction

¶1 Complementary extent accounts for marine ecosystems beyond the EEZ — including pelagic open ocean ecosystems and deep-sea floor ecosystems — can be compiled where policy-relevant. SEEA EA para. 3.33 states that such accounts "encompass the full range of relevant ecosystem assets, including those associated with pelagic ocean waters and deep-sea floors." [1] These accounts do not constitute national jurisdiction claims but provide ecological context for managing transboundary stocks and ecosystems under instruments such as the BBNJ Agreement (adopted June 2023, entered into force 17 January 2026). [2] The spatial boundary for complementary high-seas accounts should be specified in terms of FAO fishing area codes or RFMO convention area boundaries to enable linkage with fisheries reporting. [5]

3.3 Minimum Mapping Units

3.3.1 Definition and importance

¶1 The **minimum mapping unit (MMU)** is the smallest area of an ecosystem type that is separately identified and mapped in the account. The MMU is determined by the spatial resolution of the primary data source and by analytical requirements: a smaller MMU increases the representational accuracy of accounts but requires higher-resolution data and greater processing capacity. A single

MMU must be selected, documented, and applied consistently across the ecosystem accounting area and across compilation vintages (SEEA EA para. 3.44).[1] Features smaller than the MMU are either subsumed into the surrounding ecosystem type or excluded from the account.

3.3.2 MMU by data source and ecosystem type

¶1 The appropriate MMU depends on the primary data source for each ecosystem type. Table 1 provides recommended MMU ranges for the principal marine and coastal ecosystem types encountered in ocean accounts.

¶2 **Table 1: Recommended minimum mapping units by ecosystem type and primary data source**

Ecosystem type	Primary data source	Recommended MMU	Notes
Mangroves	Sentinel-2 (10 m) or Landsat (30 m)	0.5 ha	Global Mangrove Watch (GMW) baseline at ~25 m; national accounts may use finer resolution
Seagrass meadows	Sentinel-2 (10 m) or aerial survey	0.25 ha	Patchy; lower-resolution MMU appropriate for regional accounts
Coral reefs	Satellite multi-spectral (3–10 m) or Landsat	1 ha	Planet Scope or Worldview products enable finer MMU for national priority areas
Salt marshes / saltflats	Sentinel-2 (10 m)	0.5 ha	Intertidal masking required to distinguish from mud flat
Intertidal rocky shore	LiDAR, aerial survey	0.1 ha	Vertical datum alignment with tidal model required
Subtidal sandy bottom	Bathymetric survey + acoustic backscatter	1 ha	Acoustic classification at 1 m resolution supports finer MMU where available
Kelp forest	Sentinel-2 (10 m), Landsat (30 m)	1 ha	Seasonal compositing required to distinguish canopy from bare substrate
Open ocean (pelagic)	4 km Copernicus GlobColour merged ocean colour product (recommended global baseline); finer-resolution VIIRS or Sentinel-3 products may be used in national-priority areas	25 km²	25 km² is a minimum contiguous patch threshold applied after spatial aggregation to the chosen product resolution; the 4 km GlobColour product corresponds to approximately four pixels per patch threshold; finer VIIRS (750 m) or Sentinel-3 products reduce the effective MMU where higher spatial definition is required

DRAFT

¶3 These recommendations are indicative. Compilers should document the MMU applied, the primary data source and its nominal resolution, and any post-processing steps (e.g., minimum contiguous patch filtering) that affect the effective MMU.

3.3.3 Minimum mapping unit and Basic Spatial Unit resolution

¶1 The minimum mapping unit and the Basic Spatial Unit are related but distinct. The MMU is the smallest area of an ecosystem type separately identified in the account; the BSU is the tessellation cell to which all data — ecosystem type, condition, economic activity, governance designation — are referenced. A BSU cannot usefully resolve features smaller than the MMU of the data compiled into it, so the BSU side length should be set such that the cell area is no smaller than the coarsest MMU applied within the accounting area.

¶2 For a square BSU grid, cell area is the square of the side length: a 250 m cell is 6.25 ha, a 1 km cell 100 ha, a 5 km cell 2,500 ha. Reading against the MMU ranges in Table 1, this gives the following indicative correspondence for marine applications. These are starting points rather than prescriptions; the operative constraint in any national context is the spatial precision of the primary data sources.

¶3 **Table 3.3.3: Indicative BSU resolution by marine context**

Context	Indicative BSU side length	Governing MMU	Key selection criterion
Coastal zone (high data density)	100 m – 1 km	Seagrass 0.25 ha, mangrove and salt marsh 0.5 ha	Minimum width of the narrowest use zone or habitat patch to be distinguished
Offshore shelf (moderate data)	5 – 10 km	Subtidal sandy bottom, kelp 1 ha	Dominant habitat patch size from available bathymetric and ecological surveys
Deep sea and data-sparse EEZ	25 – 50 km	Pelagic 25 km²	Resolution of the best available oceanographic or benthic survey data
Small island developing States	100 m – 5 km coastal; coarser offshore	Coral reef 1 ha	Extent of coral reef and nearshore habitat systems; vessel monitoring coverage

¶4 Setting the cell size does not by itself determine the account. A cell on the edge of an ecosystem asset is only part-covered, and the rule for assigning it a single type moves the recorded extent independently of the data. Two rules are in use. Under **dominance**, the type covering the largest share of the cell takes it. Under **hierarchy**, the cell goes to the highest-priority type present, however small its share, following a priority order the compiler documents in advance. Figure 2.12.2 applies both to the same four cells.

DRAFT

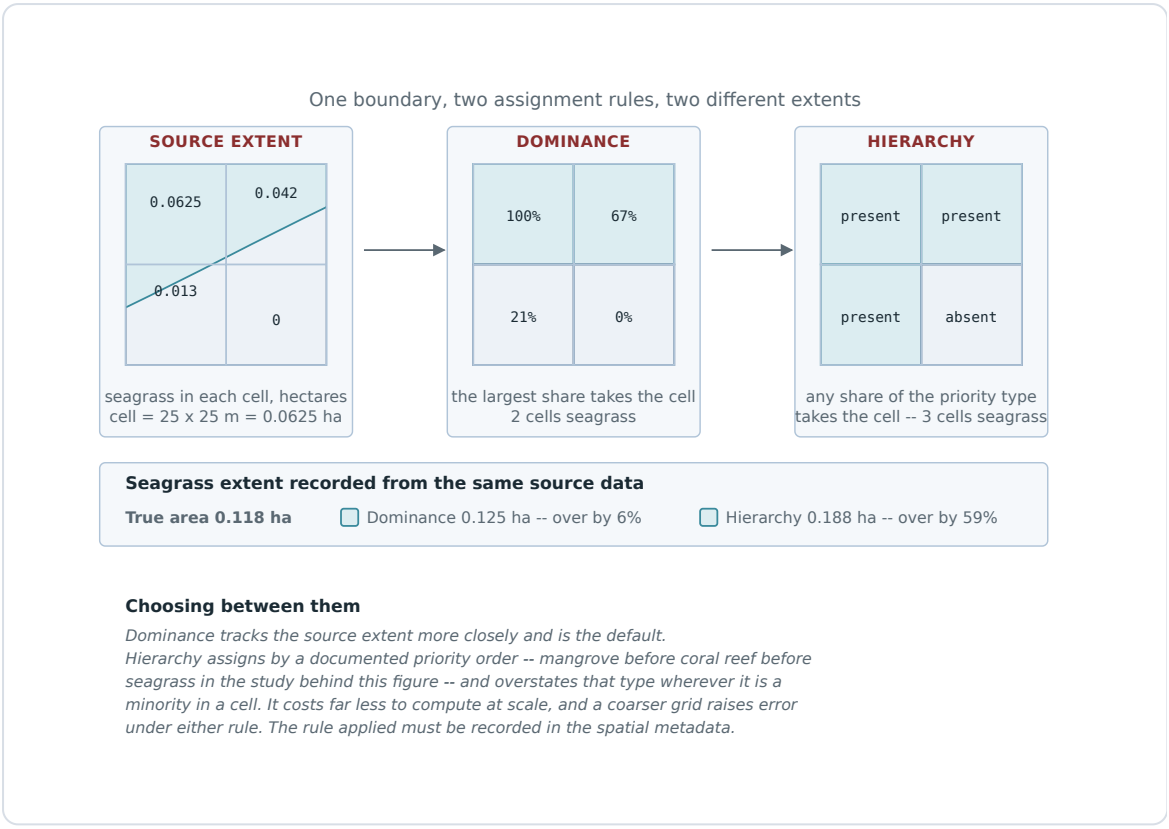


Figure 2.12.2 Where a cell is only part-covered, the assignment rule decides its type -- and the two rules return different extents from identical data.

Source: Adapted from Rahayu et al. (2024), *Optimising Marine Basic Spatial Units (MBSU) for Ocean Accounting using empirical data from Saleh Bay, Indonesia*, One Ecosystem 9: e125578, Figures 4 and 5, licensed CC BY 4.0. Cell areas are illustrative; the priority order shown is the one applied in that study.

¶5 **Dominance is the default for extent accounts**, because it tracks the source extent more closely; hierarchy systematically overstates a priority type wherever that type is a minority within a cell. Hierarchy is admissible where a documented management or reporting purpose requires a named type to be preserved wherever it occurs, and where its computational cost at national scale is the binding constraint. Empirical testing across mangrove, coral reef and seagrass in Saleh Bay, Indonesia found dominance the more accurate of the two, and found error rising under either rule as the grid coarsens.[6] The rule applied, and any priority order it uses, must be recorded in the spatial metadata alongside the MMU and BSU side length.

¶6 Marine BSU delineation raises a problem not met in terrestrial accounting: marine ecosystems are three-dimensional, and pelagic and benthic ecosystems may occupy the same horizontal location whilst representing distinct functional units. Where both are accounted, BSUs should carry a depth stratum so that the two are separately addressable rather than collapsed into a single cell.

¶7 Where data resolution improves — through new high-resolution imagery or expanded bathymetric survey — the grid may be refined. Any change in spatial resolution must be recorded as a methodological revision in the extent account for the relevant period, so that genuine ecosystem change is distinguished from reclassification arising from improved measurement (see **TG-3.1 Asset Accounts** Section 3.5.1). Countries beginning marine ecosystem accounting should start at the best available resolution and refine as data infrastructure improves.

¶8 Sensor and product resolution thresholds that constrain the achievable minimum are set out in **TG-4.1 Remote Sensing and Geospatial Data**. Sub-national accounting areas apply the same guidance through **TG-3.11 Sub-National Ocean Accounts** Section 3.1.

3.3.4 Consistency requirements

¶1 Once an MMU is adopted, it must be applied consistently across the dimensions summarised in Table 3.3.4 below.

¶2 **Table 3.3.4: MMU consistency requirements**

Dimension	Requirement
Across ecosystem types within a vintage	Do not apply different MMUs to different ecosystem types in the same compilation without explicit justification and documentation.
Across compilation vintages	Where the MMU changes between vintages (e.g., due to a new higher-resolution data source), apply a retrospective correction or document the break in series with a quantified estimate of the area difference attributable to the MMU change.
Across the EAA	Do not apply a finer MMU in priority areas (e.g., marine protected areas) without applying the same resolution to the full EAA, as this will create a systematic bias in extent estimates.

3.3.5 Remote and deep ocean data gaps

¶1 For ecosystems within the EAA that cannot be mapped due to data inaccessibility — particularly in remote offshore areas, deep-sea zones, and submarine terrain lacking bathymetric survey coverage — compilers must adopt an explicit gap treatment rather than recording a zero extent, which would falsely imply absence. The following rules apply:

- ¶2 **Observed absence vs. data gap:** Where reliable survey data confirm that an ecosystem type is absent from a defined area, zero extent is appropriate. Where absence of data merely reflects lack of survey coverage, the area should be recorded as an explicit **omission** (no-data or unknown classification) in the spatial dataset, distinguishable from confirmed-zero cells.
- ¶3 **Modelled estimates:** Where habitat suitability models, species distribution models, or other predictive approaches are used to estimate ecosystem presence in areas without direct observation, the model outputs must be flagged in ISO 19115 metadata using the DQ_CompletenessOmission data quality element (recording the extent of omitted/unobserved area) and the LI_Lineage element (documenting the model method, parameters, and spatial extent of modelled coverage), and reported as a separate component in the account from observation-based classifications. The method, model parameters, and spatial extent of modelled coverage must also be described in the account compilation notes.
- ¶4 **Uncertainty bounds for modelled estimates:** Uncertainty bounds for modelled coverage should be derived from model cross-validation statistics (e.g., AUC for presence-absence models, cross-validated RMSE for continuous outputs) and reported alongside the extent estimate in the account quality disclosure.
- ¶5 **Accuracy tier:** Account components that rely substantially on modelled estimates for deep ocean or remote areas carry a Tier 3 accuracy classification for those components, regardless of the tier applied to directly observed components. The aggregate account tier is determined by the lowest-tier component (see §3.5.3).

3.4 Temporal Consistency of Spatial Layers

3.4.1 The temporal consistency challenge

¶1 Spatial data for ocean accounts are derived from multiple sources — satellite imagery, airborne surveys, in-situ monitoring, and administrative records — each with different acquisition dates, revisit frequencies, and temporal aggregation conventions. The goal of temporal consistency is to ensure that spatial data representing different aspects of the ecosystem all refer to the same reference period, so that the account reflects a coherent snapshot of the ecosystem at a single point in time.

DRAFT

¶2 SEEA EA accounts are compiled for accounting periods aligned with the SNA — typically calendar years (1 January to 31 December). Ocean accounts must therefore assign spatial data with varying acquisition dates to a single annual reference year.

3.4.2 Reference period assignment rules

¶1 The following rules govern how multi-date spatial data are assigned to an annual reference period.

¶2 **Opening and closing stocks.** Ecosystem extent is measured as of the first and last day of the accounting period (1 January and 31 December). In practice, imagery is rarely available on exactly these dates. The compiler should select the imagery acquired closest to the target date, within a temporal window of ±90 days for ecosystems with low seasonal variability, and ±45 days for ecosystems with high seasonal variability (e.g., seagrass, which exhibits summer dieback at high latitudes).[7] The acquisition date and cloud cover of selected imagery must be documented in spatial metadata.

¶3 **Annual composites.** For dry-season compositing, a seasonal or annual composite reduces noise from cloud cover and ephemeral disturbances. For tropical ecosystems, a dry-season composite (typically April–October in the Northern Hemisphere tropics) is preferred to minimise cloud cover. For temperate ecosystems, a growing-season composite captures peak canopy cover. The temporal window for the composite must be documented.

¶4 **Seasonally variable ecosystems.** Some marine ecosystems exhibit strong seasonal extent variation (intertidal seagrass beds, algal mats). Where seasonal variation is material to policy questions (e.g., monitoring seagrass recovery under marine protected area management), compilers should consider compiling both a peak-season and an end-of-season extent to bracket the annual range, and report both in the account notes.

3.4.3 Change detection and baseline years

¶1 For change detection to be meaningful, the imagery and classification methods used for consecutive vintages must be consistent: changes in sensor, classification algorithm, or MMU between vintages will produce spurious conversions that do not reflect real ecosystem change.

¶2 Table 3.4.3 below summarises requirements that compilers should follow for change detection and baseline years.

¶3 **Table 3.4.3: Change detection and baseline year requirements**

Requirement	Description
Designate a baseline year	As the first vintage of the account series and document the imagery, classification method, and MMU used.
Apply consistent methods	For all subsequent vintages. Where a method change is unavoidable, produce a parallel classification of the baseline year using the new method to estimate the magnitude of the methodological change.
Align with SNA accounting periods	The reference year for ecosystem extent data should match the reference year of the national accounts. Where a data lag means that the latest ecosystem extent data refer to year t-1, this should be disclosed in the account and a provisional estimate for year t prepared where possible.

3.4.4 Inter-layer temporal consistency

¶1 When multiple spatial layers from different data sources are combined into a single accounting extent mosaic — for example, a mangrove layer from January, a coral reef layer from March, and a seagrass layer from October of the same reference year — the temporal spread across layers introduces a consistency risk. Apparent ecosystem conversions detected at boundaries between layers may reflect genuine land cover change or may be artefacts of the different acquisition dates, particularly for ecosystems with seasonal dynamics.

DRAFT

¶2 The following rules apply when combining spatial layers with different acquisition dates:

- ¶3 **Document acquisition dates for all layers.** The date range of all contributing layers must be recorded in the ISO 19115 lineage element for the combined mosaic dataset.
- ¶4 **Assess inter-layer lag.** Where the date range across combined layers exceeds 6 months within the same reference year, the compiler must assess whether detected ecosystem conversions at the inter-layer boundaries could be artefacts of the temporal lag. This assessment should be documented in the account quality notes.
- ¶5 **Disclose material lags.** Where a temporal lag between layers is assessed as likely to affect the extent estimates for one or more ecosystem types by more than 1% of total mapped area, this must be disclosed as a known limitation in the account quality section, together with a description of any correction or adjustment applied.
- ¶6 **Target consistent acquisition windows.** Where resources allow, compilers should target acquisition of all primary ecosystem layers within the same seasonal window (e.g., all dry-season images for a tropical account) to minimise inter-layer lag as a source of apparent conversion.

3.5 Spatial Uncertainty and Metadata Standards

3.5.1 Sources of spatial uncertainty in ocean accounts

¶1 Spatial data products used in ocean accounts carry uncertainty from multiple sources. SEEA EA paras. 2.90–2.95 identify four categories of uncertainty in ecosystem accounting: (1) uncertainty in physical measurement, (2) uncertainty in valuation, (3) uncertainty related to ecosystem dynamics, and (4) uncertainty regarding future values.[1] For spatial data specifically, the most material sources are:

Uncertainty source	Description	ISO 19115-1:2014 data quality element
Positional uncertainty	The accuracy with which mapped features correspond to their true geographic location, expressed as root-mean-square error (RMSE) in the CRS units	DQ_PositionalAccuracy
Classification uncertainty	The probability that a mapped ecosystem type correctly identifies the ecological condition of the mapped area, expressed as per-class producer's accuracy (omission error) and user's accuracy (commission error) from a confusion matrix against a probability-sampled reference dataset	DQ_ThematicClassificationCorrectness
Temporal uncertainty	The mismatch between the acquisition date of imagery and the target reference period, compounded by seasonal variation in ecosystem extent	DQ_TemporalAccuracy
Scale uncertainty	The area of unmapped ecosystems below the MMU, which constitutes a systematic downward bias in extent estimates	DQ_CompletenessOmission

DRAFT

3.5.2 Metadata standard

¶1 Spatial datasets used in ocean accounts must be documented using ISO 19115 as the minimum metadata standard.[8] Implementing agencies should adopt an ISO 19115-compliant metadata catalogue — such as GeoNetwork or ESRI Geoportal — to store and serve spatial metadata alongside account outputs.

¶2 At minimum, each spatial dataset used in an ocean account must have a metadata record that includes the elements summarised in Table 3.5.2 below.

¶3 **Table 3.5.2: Minimum metadata elements for spatial datasets in ocean accounts**

Element	Required Content
Identification	Dataset title, abstract, creation and publication date, responsible party, and CRS (EPSG code or WKT).
Quality	Positional accuracy (RMSE), classification accuracy (confusion matrix or overall accuracy), completeness (proportion of EAA covered), and temporal consistency (acquisition date range and composite window).
Lineage	Source data, processing steps, classification algorithm, and software used.
Distribution	Access URL or data custodian contact, licence, and any access restrictions.

¶4 **Licensing and redistribution.** Compilers should prefer open licences (for example, Creative Commons or equivalent open government data licences) when choosing between comparable spatial data sources, as open licences allow account outputs to be published alongside their spatial inputs, improving transparency and reproducibility. Where a spatial input is licensed under conditions that restrict redistribution, the data custodian and access pathway must be documented in the ISO 19115 Distribution element so that third parties can independently obtain the source data. The account's quality section must disclose which spatial datasets are subject to redistribution restrictions. This disclosure allows users to assess the reproducibility of the account at source level. Compilers should maintain a **data management plan** — a document recording data sources, licences, access conditions, processing steps, and long-term storage and sharing arrangements — as the primary reference for these disclosures.

¶5 **Output file formats.** Account output layers should be stored and exchanged in open, long-lived formats. For vector layers, GeoPackage (.gpkg) is recommended: it supports long attribute field names, file sizes above 2 GB, multiple geometry types within a single file, and embedded CRS and metadata. For raster layers, GeoTIFF (.tif) with embedded CRS, spatial resolution, and NoData value metadata is recommended. Shapefile (.shp) format should not be used for new output layers because of its known limitations (10-character field name truncation, 2 GB file-size ceiling, and multi-file structure that complicates archiving). Compilers operating within institutional systems that currently require Shapefile output may continue to do so, provided the limitations are documented in the metadata and a migration pathway to GeoPackage or GeoTIFF is identified in the data management plan.

¶6 **Spatial dataset version control.** Reproducibility of ocean accounts depends on future compilers being able to locate the exact version of each key spatial input dataset used. Compilers should assign a persistent identifier (DOI preferred, or alternatively a versioned URI, dataset release date tag, or national SDI version code that is uniquely resolvable) to key spatial input datasets — including the EEZ boundary layer, national coastline, and primary ecosystem classification layers — and record the identifier in the ISO 19115 metadata. Where a key input dataset is updated between compilation cycles (for example, a new VLIZ Maritime Boundaries release, a revised Global Mangrove Watch version, or an updated national hydrographic baseline), the compiler must:

- ¶7 document the version used for each accounting vintage
- ¶8 assess the spatial extent of any coverage or boundary change between versions
- ¶9 disclose any resulting difference in account totals in the account compilation notes Where a national SDI or data catalogue assigns internal version codes to official spatial layers, those codes constitute sufficient version control provided they are uniquely resolvable and recorded in the data management plan.

3.5.3 Tiered accuracy reporting

DRAFT

¶1 In data-poor contexts, full confusion matrix reporting may not be feasible. A tiered accuracy reporting scheme, adapted from established remote sensing validation frameworks, allows compilers to document uncertainty at the level achievable given available resources:

Tier	Accuracy documentation	Applicability
Tier 1	Full confusion matrix with per-class producer's and user's accuracy, derived from a probability-sampled reference dataset (≥ 50 reference points per class[9])	First-best; required for accounts that will be used in formal reporting
Tier 2	Overall accuracy statement based on a convenience sample (e.g., visual interpretation of a random sample of map polygons)	Acceptable for pilot accounts and when formal sampling is resource-constrained
Tier 3	Expert-judged qualitative confidence statement (High / Medium / Low) with a written justification referencing the data source and known limitations	Acceptable only for early-stage stub accounts; must be upgraded to Tier 2 or 1 before national reporting

¶2 The tier applied must be stated in the metadata record and in the account's quality disclosure section. When accounts compiled at different accuracy tiers are aggregated (e.g., national totals from subnational accounts), the lowest tier applies to the aggregate.

3.5.4 Uncertainty propagation

¶1 A 10% underestimate in mangrove extent translates approximately to a 10% underestimate in mangrove carbon stock value (all else equal). Compilers should:

- ¶2 Report a central estimate and, where feasible, a confidence interval (e.g., 90% confidence) for ecosystem extent by type.
- ¶3 Document the propagation pathway in the account quality disclosure, noting which downstream accounts are affected.
- ¶4 Flag monetary estimates derived from Tier 3 accuracy spatial data as provisional.

DRAFT

3.6 Worked Example: Spatial Framework for a Mangrove-Seagrass Complex

3.6.1 Context

¶1 This worked example demonstrates how the five framework dimensions apply to a national-level ocean account for a hypothetical small island developing State (SIDS) with an EEZ of approximately 400,000 km², a territorial sea of 12 nm, and a coastline featuring mangrove estuaries, seagrass beds, and fringing coral reefs.

3.6.2 CRS selection (§3.1)

¶1 The SIDS national mapping agency uses WGS84 for all official geospatial data products. The NSO adopts:

- ¶2 **Storage/exchange CRS:** WGS84 (EPSG:4326) — consistent with all incoming data from satellite operators and the national mapping agency
- ¶3 **Calculation CRS:** Equal Earth (EPSG:8857) — selected because the SIDS EEZ crosses the International Date Line, and Equal Earth avoids the antimeridian discontinuity while preserving area relationships across tropical latitudes

¶4 All agency data delivered in UTM Zone 58S (EPSG:32758) are transformed to WGS84 on ingestion, with the datum transformation documented.

3.6.3 Boundary delineation (§3.2)

¶1 The EAA outer limit is the EEZ boundary derived from the VLIZ Maritime Boundaries Geodatabase.[4] The landward boundary is defined by mean high water (MHW) derived from the national tidal model at 30-arcsecond resolution, aligned with the national mapping agency coastal zone product. Internal waters (within the archipelagic baseline) are included. Intertidal mangrove and seagrass assets that straddle the MHW datum are assigned in full to the ocean EAA, consistent with the default rule in §3.2.3. A note is added that the account does not cover high-seas complementary accounts at this stage. This omission is identified as a future development.

3.6.4 MMU selection (§3.3)

¶1 Table 3.6.4 below summarises the MMU selections made by the compiler.

¶2 **Table 3.6.4: MMU selections for the worked example**

Ecosystem Type	MMU and Rationale
Mangroves	0.5 ha — consistent with Global Mangrove Watch v3.0 (25 m native resolution) resampled to 10 m for validation with national aerial survey[10] .
Seagrass	0.5 ha — Sentinel-2 10 m classification; adopted as a conservative choice above the Table 1 recommendation of 0.25 ha due to the patchy nature of seagrass at this site and availability of WorldView validation imagery for assessment.
Coral reef	1 ha — PlanetScope 3 m classification aggregated to 1 ha polygons; sub-1 ha features excluded after finding they constitute less than 0.2% of total reef area and are below bathymetric survey resolution.

3.6.5 Temporal consistency (§3.4)

¶1 The reference period is calendar year 2023. Opening stock imagery: Sentinel-2 scenes from January 2023 (14–28 January; cloud cover < 10%); closing stock: October 2023 composite (dry season peak in this region; acquisition window 1 October — 30 October 2023). The October composite falls outside the window that §3.4.2 sets around 31 December: 1–30 October is 62–91 days before it, beyond the ±45 days allowed for seagrass and at the edge of the ±90 days allowed for the other layers. It is used as a dry-season composite (§3.4.2), and the departure is documented with a disclosure that it represents end-of-dry-season cover rather than 31 December, and that seasonal variation between October and December is estimated to be less than 5% based on historical phenology data. The three ecosystem layers (mangrove, seagrass, coral reef) are derived from different acquisition windows spanning January to October 2023 — a date range exceeding 6 months. The compiler assesses that ecosystem conversion detectable at inter-layer boundaries is unlikely to be an artefact of temporal lag given the stable dry-season conditions. This assessment is documented in the account quality notes.

3.6.6 Uncertainty and metadata (§3.5)

¶1 Table 3.6.6 below summarises the accuracy assessment for each ecosystem type.

¶2 **Table 3.6.6: Accuracy assessment for the worked example**

Ecosystem Type	Accuracy Assessment
Mangroves	Tier 1 — 75 reference points per class sampled by stratified random design; overall accuracy 94.7%; producer's accuracy (mangrove) 92.3%; user's accuracy (mangrove) 96.1%[9] .
Seagrass	Tier 2 — 40 reference points per class from diver transect data; overall accuracy 81.0%.
Coral reef	Tier 1 — 60 reference points per class; overall accuracy 88.4%[9] .

¶3 Aggregate account tier: Tier 2 (seagrass is the lowest-accuracy component). All metadata records stored in GeoNetwork instance hosted at the NSO. The account quality disclosure notes

that seagrass extent should be treated as provisional and that a full Tier 1 assessment is planned for the 2025 vintage. The VLIZ Maritime Boundaries Geodatabase release version (2023 edition, [VLIZ 2023 release DOI — to be confirmed at publication; take from the marineregions.org citation page for the version used]) is recorded in the ISO 19115 lineage metadata for the EEZ boundary layer, illustrating the version control practice recommended in §3.5.2.

¶4 Cross-references: Spatial framework outputs feed directly into **TG-3.1 Asset Accounts** for ecosystem extent account compilation and into **TG-6.2 Mangrove and Coastal Wetland Accounting** and **TG-6.3 Seagrass Ecosystem Accounting** for thematic accounts. Remote sensing data acquisition methods are documented in **TG-4.1 Remote Sensing and Geospatial Data**.

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

5. References

1. ¶1 United Nations. (2021). *System of Environmental-Economic Accounting — Ecosystem Accounting* (SEEA EA). Adopted as a statistical standard by the United Nations Statistical Commission at its 52nd session, March 2021. Paras. 3.1–3.89, 2.90–2.95.
2. ¶2 United Nations. (1982). *United Nations Convention on the Law of the Sea* (UNCLOS). Entered into force 1994. Parts II, V, VI. Available at: https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf (https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf).
3. ¶3 Commission on the Limits of the Continental Shelf (CLCS). (1999). *Scientific and Technical Guidelines of the Commission on the Limits of the Continental Shelf*. CLCS/11. New York: United Nations. Defines the foot-of-the-slope formula and fixed points used to determine the outer limits of the continental shelf under UNCLOS Article 76.
4. ¶4 Flanders Marine Institute (VLIZ). *Maritime Boundaries Geodatabase*. Available at: https://www.marineregions.org/ (https://www.marineregions.org/). Used for EEZ outer limit delineation consistent with UNCLOS.
5. ¶5 Food and Agriculture Organization of the United Nations (FAO). *FAO Major Fishing Areas*. Available at: https://www.fao.org/fishery/en/area/search (https://www.fao.org/fishery/en/area/search). FAO statistical area codes provide a globally consistent spatial reference for high-seas and straddling-stock fisheries data that can be linked to complementary ocean extent accounts.
6. ¶6 Rahayu, A.K., Arhatin, R.E., Gacutan, J., Agung, F., Pingkan, J., Rosdiana, A., & Yulianto, I. (2024). Optimising Marine Basic Spatial Units (MBSU) for Ocean Accounting using empirical data from Saleh Bay, Indonesia. *One Ecosystem*, 9, e125578. DOI: 10.3897/oneeco.9.e125578. Tested 10 x 10 m and 25 x 25 m grids against dominance and hierarchy assignment over mangrove, seagrass and coral reef extent delineated in 2021. Licensed CC BY 4.0.
7. ¶7 The ±90 day and ±45 day temporal windows reflect standard remote sensing compositing practice for low- and high-variability ecosystems respectively. The tighter window for high-variability ecosystems (e.g., seagrass exhibiting seasonal dieback) is consistent with the temporal consistency principles in Olofsson et al. (2014)[9]. Compilers should justify any departures from these windows in their spatial metadata.
8. ¶8 International Organization for Standardization. (2014). *ISO 19115-1:2014 — Geographic information — Metadata — Part 1: Fundamentals*. Geneva: ISO. The standard defines the schema required for describing geographic information and services.
9. ¶9 Olofsson, P., and others. (2014). Good practices for estimating area and assessing accuracy of land change. *Remote Sensing of Environment*, 148, 42–57. Provides the statistical sampling framework for Tier 1 accuracy assessment described in Section 3.5, including the minimum reference point threshold (≥ 50 points per class) and temporal consistency requirements for change detection.
0. ¶10 Bunting, P., Rosenqvist, A., Dhargay, S., Higgins, J., Woodhouse, I., Joshi, N., and others. (2022). Global Mangrove Watch Version 3.0 — Updated Mangrove Extent for the Year 2020. *Remote Sensing*, 14(15), 3657. Provides the global mangrove baseline used in Section 3.3 MMU guidance and the worked example in Section 3.6.

DRAFT

Governance and Institutional Indicators

Compiles governance and institutional indicators from ocean governance accounts, measuring the quality.

Version 0.7.3 **Status** Draft **Stability** Emerging

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

OUTCOME

After working through this Circular, readers will be able to compile governance and institutional indicators from ocean governance accounts, measuring the quality, effectiveness, and coverage of institutional arrangements governing ocean use and conservation. Readers will understand how to derive indicators across five principal dimensions: legal framework coverage, MPA management effectiveness, tenure and access rights security, compliance and enforcement performance, and institutional capacity. Readers will also learn to interpret these indicators using a governance stocks-and-flows analytical framework. The guidance includes a worked example drawn from the Indonesia Gili Matra MPA pilot. It supports national monitoring of SDG 14.2, SDG 14.C, SDG 16.6, and SDG 16.7, and draws on the governance accounts methodology in TG-3.7 Governance Accounts and the general indicator methodology in TG-2.1 Aggregate Biophysical Indicators of Environmental State.

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 3
3.1 Governance Indicator Framework 4
3.2 Legal Framework Coverage Indicators 7
3.3 MPA Management Effectiveness Indicators 8
3.4 Tenure and Access Rights Indicators 9
3.5 Compliance and Enforcement Indicators 10
3.6 Institutional Capacity Indicators 11
3.7 Compilation Procedure 12
3.8 Worked Example: Gili Matra Marine Protected Area (Indonesia) 14
4. Acknowledgements 15
5. References 16

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Governance and Institutional Indicators (2026) (GOAP Technical Guidance on Ocean Accounting, TG-2.13, v0.7.3). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-2/2-13-governance-institutional-indicators/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

1. Outcome

¶1 After working through this Circular, readers will be able to compile governance and institutional indicators from ocean governance accounts, measuring the quality, effectiveness, and coverage of institutional arrangements governing ocean use and conservation. Readers will understand how to derive indicators across five principal dimensions: legal framework coverage, MPA management effectiveness, tenure and access rights security, compliance and enforcement performance, and institutional capacity. Readers will also learn to interpret these indicators using a governance stocks-and-flows analytical framework. The guidance includes a worked example drawn from the Indonesia Gili Matra MPA pilot. It supports national monitoring of SDG 14.2, SDG 14.C, SDG 16.6, and SDG 16.7[1], and draws on the governance accounts methodology in **TG-3.7 Governance Accounts** and the general indicator methodology in **TG-2.1 Aggregate Biophysical Indicators of Environmental State**.

2. Requirements

¶1 **Essential prerequisites:**

- ¶2 **TG-3.7 Governance Accounts** — compiled governance account data (legal framework registers, MPA management records, tenure registry data, enforcement statistics) that underpin all indicators in this Circular
- ¶3 **TG-0.1 General Introduction to Ocean Accounts** — conceptual framework connecting governance arrangements to ecosystem and economic outcomes

¶4 **Helpful background:**

- ¶5 **TG-0.2 Overview of Relevant Statistical Standards** — international statistical standards underpinning ocean accounting
- ¶6 **TG-2.1 Aggregate Biophysical Indicators of Environmental State** — general indicator methodology, including normalisation and composite index construction
- ¶7 **TG-6.6 Deep Sea and ABNJ Accounting** — ecosystem accounting methods in Areas Beyond National Jurisdiction, relevant to BBNJ governance indicator tracking

¶8 ⓘ **Framework Position**

¶9 This Circular addresses how governance accounts capture the institutional arrangements that mediate between economic activity and ecosystem outcomes. In the Ocean Accounts Framework (TG-0.1 Figure 0.1.2), governance operates on all edges:

Edge	Direction	Description
E1	FG1 → SG3	Regulates pollution and residuals from economy to environment
E9	SG3 → FG1	Governs access to ecosystem services by the economy
E10	SG3 → FG2	Governs ecosystem service access by society
E5	FG2 → SG3	Shapes social management of environmental assets

¶10 Governance operates across multiple framework edges in its dual role as regulator of flows (constraining and enabling E1, E9, E10, E5) and as a social asset (SG2) enabling both economic and social activities (E7, E8). See TG-3.7 Governance Accounts for the asset framing.

3. Guidance Material

¶1 Governance of ocean systems encompasses the legal, institutional, and procedural arrangements through which societies make and implement decisions about ocean use, protection, and dis-

DRAFT

tribution of benefits [2]. Ocean governance accounts (TG-3.7) systematise the data on these arrangements into a coherent statistical framework. This Circular translates that data into indicators suitable for policy monitoring and international reporting.

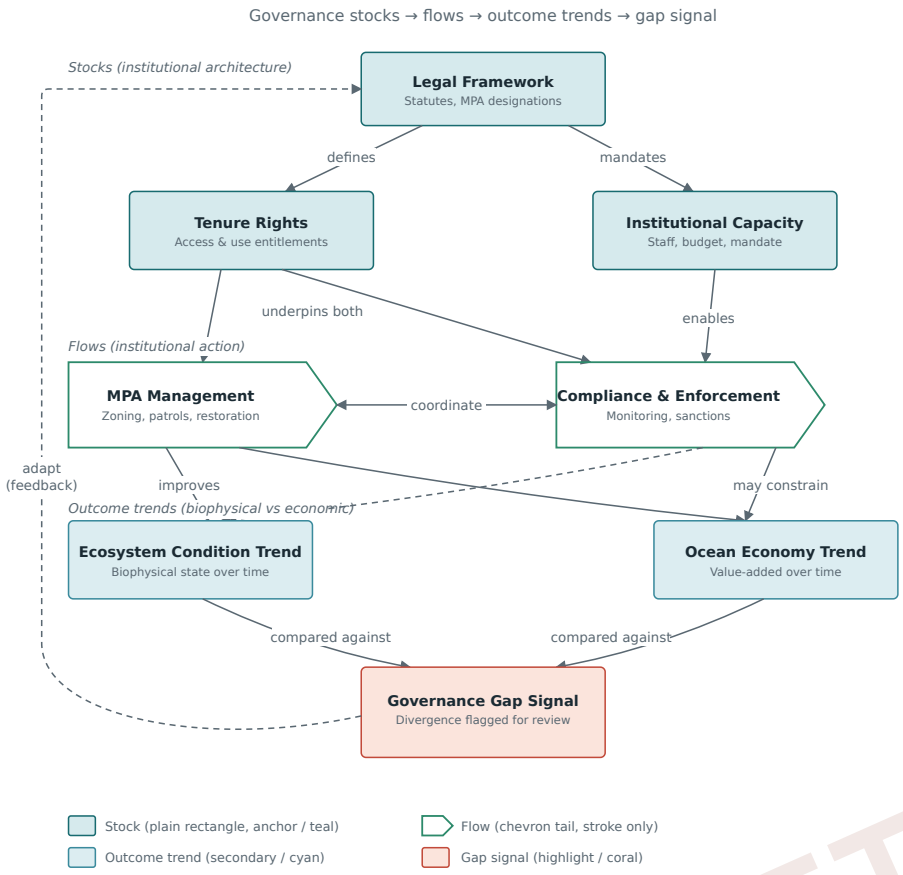
¶2 ⚠ **Emerging Practice**

¶3 Governance and institutional indicator compilation is an emerging area of practice. The indicator framework presented here reflects current methodological thinking but has not been formally validated across a wide range of country contexts. Practitioners should treat scoring rubrics and composite index weights as provisional and document any adaptations to national circumstances. Where national governance indicators diverge from the indicator definitions in this Circular, differences should be reported in indicator metadata to support cross-country comparison.

3.1 Governance Indicator Framework

¶1 Figure 2.13.1 illustrates how the Legal Framework, as the foundational governance stock, defines the tenure rights regime and mandates institutional capacity. These instrument stocks supply the governance flows (MPA management, compliance and enforcement) that drive ecosystem condition and ocean economy trends. Divergence between these trends signals a governance gap that feeds back into institutional adaptation.

DRAFT



DRAFT

Figure 2.13.1 Governance stocks (legal framework, tenure, capacity) supply management and enforcement flows that shape condition and economy trends. Rectangles = stocks; chevrons = flows. Dashed loop = adaptation feedback, not a measured flow.

Source: TG-2.13 draft, §3.1.4 stocks-and-flows analytical framework; §3.8 Gili Matra worked example (Tables 2-4); SEEA EA Section 13.5 and paras 1.13-1.18 (governance and institutional context).

Adapted from: SDG 14.5 (MPA coverage); Kunming-Montreal GBF Target 3 (protected-area effectiveness); IPBES governance framework (institutional stocks-and-flows distinction).

3.1.1 Dimensions of ocean governance

¶1 Ocean governance indicators span five analytically distinct dimensions, each corresponding to a component of governance accounts compiled under TG-3.7[3]. Table 3.1.1 below summarises these dimensions.

¶2 **Table 3.1.1: Dimensions of ocean governance indicators**

Dimension	Description
Legal framework coverage	Measures whether the legal and policy instruments required for sustainable ocean management are in place — fisheries laws, marine protected area enabling legislation, coastal zone management acts, and their alignment with international obligations including UNCLOS[4].
Management effectiveness	Measures whether the institutions and processes tasked with ocean management perform their functions — whether management plans are developed and implemented, whether monitoring and evaluation systems are operating, and whether management decisions are informed by evidence.

Dimension	Description
Tenure and access rights security	Measures whether ocean-dependent resource users have legally recognised rights that provide security of access and create incentives for stewardship — fishing licences, community tenure arrangements, and IPLC customary use rights.
Compliance and enforcement	Measures whether legal obligations are being respected and enforced — detection and sanction of illegal fishing and other violations, flag state control performance, and port state inspection records.
Institutional capacity	Measures whether the institutions responsible for ocean governance have the human, financial, and technical resources to fulfil their mandates — staffing levels, budget allocations, and inter-agency coordination mechanisms.

¶3 A sixth dimension, **climate-adaptive governance**, is increasingly recognised as relevant to ocean governance assessment. This dimension measures whether governance frameworks incorporate adaptive management provisions, climate risk assessment requirements, and flexible spatial management mechanisms that can accommodate climate-driven shifts in species distributions and ecosystem boundaries. Methods for assessing climate-adaptive governance quality are still developing. Compilers interested in this dimension should consult the climate indicator framework in TG-2.8 Climate Change Indicators and document existing adaptive provisions as a narrative component of governance accounts.

3.1.2 Relationship to SDG and international frameworks

¶1 Table 1 maps governance indicator dimensions to relevant SDG and international monitoring frameworks, providing the reporting linkages that underpin compilation priorities.

¶2 **Table 1: Governance Indicator Dimensions and International Framework Mapping**

Governance Dimension	SDG Indicator	International Framework
Legal framework coverage	SDG 14.C.1	UNCLOS implementation
MPA management effectiveness	SDG 14.2.1, SDG 14.5.1	Kunming-Montreal GBF Target 3
Tenure and access rights	SDG 14.b.1	SSF Guidelines
Compliance and enforcement	SDG 14.6.1	IPOA-IUU, PSM Agreement
Institutional capacity	SDG 16.6.1	Open Government Partnership
Participation and community voice	SDG 16.7.2	Aarhus Convention; SSF Guidelines Part 6

DRAFT

¶3 Participation indicators are documented in governance accounts per TG-3.7 §3.1 and can be compiled alongside the five primary indicator dimensions.

¶4 KM-GBF Target 3 requires that marine protected areas be "effectively" managed [5], making MPA management effectiveness indicators directly relevant to national GBF reporting beyond the 30×30 area metric.

¶5 The FAO Small-Scale Fisheries Guidelines establish international recognition of secure and equitable access rights for small-scale fishers [6]. Tenure security indicators serve as the accountability mechanism for SSF Guidelines implementation.

¶6 SDG 14.6.1 measures progress in implementing international instruments to combat IUU fishing [7], for which compliance and enforcement indicators provide the quantitative underpinning.

¶7 For indicators tracking national implementation of multilateral environmental agreements more broadly, see TG-2.10 Multilateral Environmental Agreement Indicators. For governance and indicator implications of the BBNJ Agreement, see TG-6.6 Deep Sea and ABNJ Accounting. Compilers should track national ratification progress and document operational BBNJ implementation indicators as a data gap pending further international methodological guidance [8].

3.1.3 Relationship to biophysical and economic outcomes

¶1 Improvements in governance quality can precede measurable changes in ecosystem condition and economic performance, though the causal pathways and time lags are often long and context-dependent. A country may show declining biophysical condition despite strong governance scores if governance improvements are recent. Conversely, stable biophysical indicators may mask governance deterioration if legacy institutional arrangements are eroding.

¶2 Compilers should present governance indicators alongside the relevant biophysical and economic outcome indicators from TG-2.1 through TG-2.7 Pollution Flows and Pressures Indicators to support integrated assessment. Correlations between, for example, MPA management effectiveness scores and coral reef condition indicators provide empirical material for exploring potential relationships, though attribution remains subject to the causal and time-lag caveats above.

3.1.4 Governance Stocks and Flows

¶1 A useful analytical distinction within the governance accounts framework separates **governance stocks** from **governance flows**, following the accounting logic of the System of National Accounts as applied in the SEEA [9].

¶2 **Governance stocks** are the institutional arrangements existing at a specific point in time — the architecture of the governance system. In the marine domain, governance stocks include: the spatial extent of marine jurisdictions (territorial sea, EEZ, ABNJ zones); the legal instruments in force (fisheries acts, MPA enabling legislation, coastal zone management acts); rights allocations (fishing licences, quota allocations, TURF designations); MPA zoning designations and associated management plans; and formal co-management agreements with IPLCs or community groups. Governance stocks map directly onto the legal framework coverage and tenure and access rights dimensions described in Section 3.1.1. Within this architecture the legal framework is foundational: statutes and enabling legislation define the tenure and access rights regime and confer the institutional mandates that capacity is resourced to fulfil, so the three stock dimensions are not fully independent.

¶3 **Governance flows** are the activities, transactions, and interventions generated by the institutional architecture over a defined accounting period. Governance flows include: enforcement actions taken (boardings, inspections, prosecutions); management expenditures disbursed; revenue collected from taxes, resource rent and administrative fees; compliance monitoring patrols conducted; observer deployments; and measurable stakeholder participation in decision-making processes. Expenditure and revenue flows are recorded gross and separately, in the two distinct accounting modules set out at TG-3.7 Section 3.3.5: expenditure belongs to the environmental activity accounts, revenue to the environmental transactions module. Indicators in this Circular are therefore constructed on one side or the other, and no indicator should net governance revenue against governance expenditure. Where a cost-recovery ratio is reported, it must be labelled as an analytical ratio and state both gross figures. They correspond to the compliance and enforcement and institutional capacity dimensions described in Section 3.1.1.

¶4 The stock-and-flows framing exposes a common governance failure pattern: the governance stock may appear well-developed (a management plan exists, zones are legally designated, rights are formally allocated) whilst governance flows are inadequate, meaning enforcement is absent, management budgets are unspent, and monitoring is not conducted. The Gili Matra pilot (Section 3.8) illustrates this pattern empirically. Compilers should assess and present both the stock architecture and the flow performance of governance systems together. The management effectiveness indicators in Section 3.3 and compliance indicators in Section 3.5 operationalise governance flow performance. Legal framework and tenure indicators in Sections 3.2 and 3.4 operationalise governance stock coverage.

3.2 Legal Framework Coverage Indicators

3.2.1 Ocean legislation registry

DRAFT

¶1 The governance accounts compiled under TG-3.7 include a legal framework register recording the existence, date of adoption, and implementation status of key ocean governance instruments. Table 3.2.1 below summarises the indicators derived from this register.

¶2 **Table 3.2.1: Indicators derived from the ocean legislation registry**

Indicator	Description
Proportion of EEZ covered by fisheries legislation	Whether the national fisheries law provides coverage for all waters within the EEZ, or is limited to territorial sea or archipelagic waters; gaps in legislative coverage create unregulated zones that undermine stock management.
Alignment of fisheries legislation with international instruments	Scored assessment of whether the national fisheries act implements the key obligations under UNCLOS (Articles 61 and 62 on conservation and utilisation), the UN Fish Stocks Agreement, and the FAO Code of Conduct for Responsible Fisheries[10] ; scored as 0 (no legislation), 1 (legislation exists but does not address obligations), 2 (partial alignment), 3 (full alignment).
Marine spatial planning legislative basis	Whether a legal instrument provides authority for binding marine spatial plans, or whether planning is conducted on a non-binding advisory basis; binding plans create enforceable mechanisms for resolving competing uses.
Coastal zone management legislation	Existence and coverage of integrated coastal zone management legislation that coordinates terrestrial and marine jurisdictions.
Environmental impact assessment coverage	Whether EIA requirements apply to all ocean-related development activities, including offshore energy, aquaculture, and port development, and whether EIA processes incorporate ecosystem accounts data.

3.2.2 International obligations coverage

¶1 **UNCLOS implementation score** — SDG indicator 14.C.1 measures progress in implementing UNCLOS through legal, policy and institutional frameworks[11] . Governance accounts provide the data for scoring national implementation across the seven dimensions of the SDG 14.C.1 methodology (see Section 3.7.4 for the DOALOS voluntary national reporting tool used in compilation).

¶2 **Regional fisheries body participation** — proportion of stocks within national jurisdiction that fall under the management framework of a Regional Fishery Management Organisation (RFMO) or Regional Fishery Body (RFB) to which the country is a member or cooperating non-contracting party (a status allowing non-member states to participate in conservation obligations without full membership rights).

¶3 **Port State Measures Agreement implementation** — scored assessment of national implementation of PSMA obligations: port designation, advance notification requirements, inspection procedures, and information sharing with flag states and RFMOs[12] .

3.2.3 Relationship to Macroeconomic Governance Indicators

¶1 The World Bank Worldwide Governance Indicators (WGI) provide annual composite scores for six governance dimensions across more than 200 economies[13] . National WGI scores may provide useful macroeconomic context — compilers may note them as metadata when reporting governance indicator results.

¶2 The WGI framework is insufficiently granular for sector-specific ocean governance assessment: its six dimensions characterise whole-of-government performance at national scale and cannot capture MPA management quality, fishing rights security, or compliance patrol intensity. Where country-level WGI data are available, compilers may note in indicator metadata the degree of alignment or divergence between national governance scores and sector-level ocean governance indicator values, as this divergence can itself be analytically informative.

3.3 MPA Management Effectiveness Indicators

DRAFT

3.3.1 Coverage and representativeness

¶1 **Marine area under formal protection (%)** — proportion of the national marine jurisdiction (territorial sea + EEZ) designated as marine protected areas, marine reserves, or other effective area-based conservation measures (OECMs). This is the metric tracked by SDG 14.5.1, SDG 14.2.1 (proportion of national EEZ managed using ecosystem-based approaches), and KM-GBF Target 3.

¶2 **Ecosystem representativeness** — proportion of each major marine ecosystem type (coral reefs, seagrass meadows, mangroves, pelagic zones, seamounts) covered by protected areas, measured in hectares and as a proportion of total ecosystem extent from ecosystem extent accounts (TG-3.1 Asset Accounts for the Ocean).

¶3 **Protection level classification** — distribution of protected areas across IUCN protection categories (I-VI), indicating the range of restrictions on extractive and other activities within the protected area network. Areas under strict protection (Categories I-II) are distinguished from those permitting sustainable use (Categories V-VI).

3.3.2 Management effectiveness scoring

¶1 **METT-4 score** — Management Effectiveness Tracking Tool (METT-4) score averaged across all MPAs in the national system, measuring six dimensions: context, planning, inputs, processes, outputs, and outcomes[14]. METT-4 is the primary global tool for MPA management effectiveness assessment and is used for KM-GBF Target 3 "effective" reporting.

¶2 **Proportion of MPAs with current management plans** — MPAs with a management plan adopted within the past five years as a proportion of all designated MPAs.

¶3 **Proportion of MPAs with operational monitoring programmes** — MPAs with documented, regularly implemented biological and compliance monitoring as a proportion of all designated MPAs.

¶4 **Staff-to-area ratio** — number of full-time equivalent management staff per 1,000 km² of protected area. Consistent with the staffing data compiled in governance accounts (TG-3.7), this indicator is standardised by area to enable cross-site and cross-country comparison.

¶5 **MPA management budget per km²** — recurrent management expenditure (excluding capital) per km² of protected area, derived from the institutional expenditure accounts in TG-3.7. Budget-to-area ratios below empirically established minimum thresholds (typically USD 600–2,500 per km² depending on location, management intensity, and ecosystem type) may indicate severe resource constraints[15].

3.3.3 Ecological effectiveness

¶1 **Condition differential (MPA vs. non-MPA)** — comparison of ecosystem condition indicators (coral cover, fish biomass, seagrass density) inside and outside MPAs, controlling for environmental gradients. A positive differential indicates that MPAs are generating ecological benefits. The absence of a differential suggests enforcement or management failure. This indicator integrates governance accounts data (MPA boundaries and management quality) with condition account data from TG-3.1 Asset Accounts for the Ocean.

¶2 **Spillover index** — estimated biomass of target fish species in the unprotected zone adjacent to MPAs as a proportion of MPA interior biomass, measuring whether MPAs are generating fisheries benefits for adjacent communities through adult spillover[16].

3.4 Tenure and Access Rights Indicators

3.4.1 Fishing rights coverage and security

¶1 **Proportion of fishing effort under formal rights instruments** — fishing effort (days at sea or gross registered tonnes-days, GRT-days, where GRT-days are a measure of vessel capacity utilisa-

DRAFT

tion combining gross registered tonnage with fishing days) under formal fishing licences, individual transferable quotas, territorial use rights in fisheries (TURFs), or community rights agreements as a proportion of total estimated fishing effort.

¶2 **Fishing rights security index** — composite indicator of rights security, drawing on governance accounts data on:

- ¶3 Duration of rights (long-term rights score higher than seasonal or annual licences)
- ¶4 Transferability (tradeable rights score higher)
- ¶5 Exclusivity (exclusive rights score higher than non-exclusive)
- ¶6 Legal basis (statutory rights score higher than administrative allocations)

¶7 Each criterion is scored 0–3 (0: absent; 1: limited; 2: moderate; 3: strong). The composite index is the unweighted mean of the four criterion scores, normalised to 0–100 by multiplying by 100/3. Compilers should document and justify any alternative weighting scheme using the composite index procedure in TG-2.1 Aggregate Biophysical Indicators of Environmental State, Section 3.4.3.

¶8 **Small-scale fisheries (SSF) rights coverage** — proportion of small-scale fishing households with documented access rights to their primary fishing grounds. This indicator operationalises SDG 14.b.1 (progress on implementation of the SSF Guidelines)[17] and should be disaggregated by sex and IPLC status where data permit.

¶9 **IPLC customary rights recognition** — proportion of IPLC communities with ocean-based customary use areas that have received formal legal recognition of their rights, either through statutory instruments, co-management agreements, or customary fishing area designations. Formal recognition is distinguished from mere acknowledgement in policy documents.

3.4.2 Rights equity and distribution

¶1 **Gender equity in fishing rights** — proportion of formal fishing licence holders who are women, and proportion of fishing quota or community rights allocations held by women's organisations. Disaggregated by gear type and fishing area. Governance accounts should record rights holder identity disaggregated by sex where administrative records allow. Data for this indicator should be drawn from social accounts compiled per TG-3.5 Social Accounts, Section 3.2 on rights and access disaggregation.

¶2 **Gini coefficient for fishing quota distribution** — inequality in the distribution of quota or fishing effort allocations across rights holders, where transferable quota systems exist. This indicator applies only in jurisdictions with tradeable quota systems (ITQs or similar), whilst in licensing or effort-based fisheries management systems, alternative distribution metrics such as the proportion of licensed effort held by small-scale versus large-scale operators may be substituted.

¶3 **Community tenure area** — hectares of marine area subject to community tenure arrangements (TURFs, locally managed marine areas, community conserved areas), and this area as a proportion of total managed marine area.

3.5 Compliance and Enforcement Indicators

3.5.1 IUU fishing and compliance

¶1 **IUU fishing prevalence index** — estimated proportion of total catch in national waters attributable to illegal, unreported, and unregulated (IUU) fishing, derived from catch reconstruction applied to governance accounts data on reported and estimated actual catches. For estimation methods (port sampling, observer programmes, VMS comparison, stock-assessment back-calculation, trade-based analysis, satellite surveillance) and the SEEA CF accounting treatment, see TG-4.10 Extending Fisheries Statistics Section 3.8.4. This indicator is the outcome measure against which enforcement performance indicators should be assessed.

DRAFT

¶2 **Vessel monitoring system (VMS) coverage** — proportion of commercial fishing vessels above the licensing threshold that are equipped with operational VMS transponders and transmitting to the national fisheries monitoring centre.

¶3 **Observer coverage rate** — proportion of commercial fishing trips with on-board fisheries observers (human or electronic), by gear type and fleet segment. Observer coverage significantly below 20% is generally considered insufficient for reliable catch verification in high-value fisheries in many contexts, though appropriate coverage rates depend on fishery type and risk level — some RFMOs require 100% coverage (human or electronic) for high-value tuna fisheries [18].

¶4 **Boarding and inspection rate** — number of at-sea boardings per 1,000 commercial fishing vessel days, indicating the probability of inspection that a vessel faces.

¶5 **Violation detection and prosecution rate** — proportion of detected fishing violations that result in formal charges, sanctions, or permit revocation. A high detection-to-prosecution ratio indicates an effective enforcement chain, whilst a low ratio suggests administrative or judicial bottlenecks.

¶6 Satellite-based monitoring is increasingly providing proxy enforcement indicators that can supplement administrative enforcement records where data coverage is weak. Technologies such as Automatic Identification System (AIS) vessel tracking, as operationalised through platforms such as Global Fishing Watch, can generate measurable proxies including vessel days in MPAs, AIS transponder activity rates, and dark vessel detection rates in designated zones. These emerging data sources may be especially useful in contexts where on-water patrol capacity is limited, though compilers should treat them as supplementary rather than primary compliance indicators pending broader methodological validation [19].

3.5.2 Flag and port state control

¶1 **Flag state control performance** — proportion of vessels flagged to the country that have been inspected by port state control authorities in foreign ports and found to have fishing-related deficiencies, sourced from RFMO IUU vessel lists and port state inspection databases.

¶2 **Port state inspection coverage** — proportion of foreign fishing vessels calling at national ports that are subject to PSM Agreement inspection requirements and that receive documentary or physical inspection, measuring compliance with PSMA obligations [20].

¶3 **IUU vessel listing** — number of vessels flagged to the country appearing on RFMO IUU vessel lists during the reference year, indicating flag state control failures.

3.6 Institutional Capacity Indicators

3.6.1 Human and financial resources

¶1 **Fisheries management staff per 1,000 active fishers** — full-time equivalent staff in the national fisheries authority per 1,000 licensed or registered commercial and small-scale fishers.

¶2 **Ocean governance budget as share of ocean economy GDP** — total recurrent expenditure on fisheries management, MPA management, coastal monitoring, and related governance functions as a proportion of ocean economy GDP (as compiled under TG-2.5 Ocean Economy Structure and Activity).

¶3 **Fisheries research expenditure intensity** — expenditure on stock assessment, ecosystem monitoring, and fisheries science as a proportion of total fisheries management expenditure, indicating the share of capacity devoted to the evidence base for management decisions.

3.6.2 Coordination and integration

¶1 **Inter-agency ocean coordination score** — scored assessment of the effectiveness of formal coordination mechanisms between the fisheries authority, environment/conservation agency,

DRAFT

coastguard/maritime enforcement, tourism authority, and other relevant bodies. Scoring criteria are applied as follows: (1) existence of a formal inter-agency coordination body; (2) meeting frequency; (3) joint planning processes; (4) shared data systems; (5) joint enforcement operations. Score each criterion 0 (absent), 1 (exists but not operational), 2 (operational but limited), 3 (fully operational and effective). Average across criteria: 0.0–1.0 = weak coordination; 1.1–2.0 = partial coordination; 2.1–3.0 = effective coordination. The coordination score methodology is consistent with TG-3.7 §3.6 coordination effectiveness scoring.

¶2 **Marine spatial plan adoption and implementation** — binary indicator of whether a binding marine spatial plan covering at least 50% of national waters is in force, plus a scored assessment of plan implementation status. Draws on legal framework data (Section 3.2) and governance accounts process records (TG-3.7).

¶3 **Integrated coastal monitoring system coverage** — proportion of the coastline covered by an integrated monitoring system that combines biophysical data (condition accounts), economic activity data (economic accounts), and governance compliance data (enforcement records), enabling evidence-based adaptive management.

3.7 Compilation Procedure

3.7.1 Step 1: Assemble governance account data

¶1 Governance and institutional indicators are derived from the governance accounts compiled under TG-3.7. Before indicator compilation, confirm that the following governance account components are available and current:

- ¶2 Legal framework register (Section 3.7.2 of TG-3.7)
- ¶3 MPA register with METT-4 assessments and management plan status
- ¶4 Rights registry: fishing licences, quotas, TURFs, community agreements
- ¶5 Enforcement records: inspections, boardings, detections, prosecutions
- ¶6 Institutional budget and staffing records

¶7 Where governance account data are incomplete, note data gaps in indicator metadata and apply conservative assumptions rather than extrapolating from incomplete records.

DRAFT

3.7.2 Step 2: Calculate indicator values

¶1 For each indicator, apply the formula or scoring procedure specified in Sections 3.2 through 3.6, drawing on the relevant governance account component. Record the numerator, denominator, and source data reference for each indicator to enable verification and updating.

¶2 **Scoring indicators.** Where indicators involve scored assessments (legal framework alignment, inter-agency coordination), apply the scoring rubric consistently across all spatial units or time periods being assessed. Document the scoring criteria and, where expert judgement is involved, identify the assessor and date of assessment.

¶3 **Composite indicators.** Where composite indicators aggregate multiple sub-indicators (fishing rights security index, composite governance indicator (Section 3.8.5)), apply the normalisation and weighting procedure from **TG-2.1 Aggregate Biophysical Indicators of Environmental State**, Section 3.4.3 on composite index construction. The weighting scheme and normalisation method must be documented.

> *Worked compilation: Fishing rights security index (§3.4.1)*
> *Data source: Rights registry component of the TG-3.7 governance accounts. Each fishing right entry records: duration class (annual / multi-year / permanent), transferability flag, exclusivity class, and legal basis type.*

> *Step 1 — Score each criterion per the scoring rubric in §3.4.1.*
> *Step 2 — Average across criteria for each rights class and compute the composite: Unweighted mean of the four criterion scores. Normalise to 0–100: index = (mean score ÷ 3) × 100.*
> *Example: A small-scale fishing community holds 5-year TURFs, transferable within the community, exclusive to licence holders, established by fisheries regulation: Duration = 2, Transferability = 1, Exclusivity = 2, Legal basis = 2. Mean = 7 ÷ 4 = 1.75. Index = (1.75 ÷ 3) × 100 = **58.3**.*
> *Step 3 — Aggregate across rights classes: Where a fishery has multiple rights instruments (e.g., commercial licences and community TURFs), compute a weighted average using fishing effort (days at sea or GRT-days) as the weight, then report the overall index alongside the disaggregated class-level scores.*
> *Step 4 — Record metadata: Source register (TG-3.7 rights registry), reference year, number of rights entries scored, assessor, and any rights classes where data were incomplete.*

3.7.3 Step 3: Temporal and spatial disaggregation

¶1 Governance indicators should be compiled at the same temporal and spatial resolution as the governance accounts from which they are derived. For most indicators, an annual compilation cycle aligned with the governance accounts reference year is appropriate.

¶2 **Spatial disaggregation.** Where governance accounts are compiled at sub-national level (provincial, district, or management unit), governance indicators should be reported at that level to support sub-national policy analysis. The sub-national governance accounts methodology is addressed in **TG-3.11 Sub-National Ocean Accounts**.

¶3 **Temporal trends.** A minimum of three reference years is needed to identify trend direction. Five or more years is recommended for tracking reform impacts.

3.7.4 Step 4: SDG and international reporting

¶1 Map compiled indicator values to the relevant SDG metadata frameworks and international reporting obligations identified in Table 1. Where national governance indicators use different methodologies from the SDG global indicator standards, document the methodological alignment and note any adjustments applied to produce SDG-compatible values.

¶2 For SDG 14.C.1 reporting, the governance account data support the structured assessment across the seven implementation dimensions of the voluntary national reporting tool developed by the UN Division for Ocean Affairs and the Law of the Sea (DOALOS)[21].

3.7.5 Step 5: Data quality flags and limitations

¶1 Governance data are subject to quality constraints that compilers should document systematically. Common data gaps include: incomplete administrative records for enforcement activities (inspection logs, prosecution outcomes); inconsistent licensing database formats across agencies; and delayed or partial reporting from subnational institutions. Where scoring on qualitative governance dimensions involves expert judgement, the assessor, date, and scoring rationale should be recorded as metadata attached to the indicator value.

¶2 Several governance indicators may be politically sensitive in some country contexts — enforcement failure rates, IUU vessel listings, and compliance rates may reflect negatively on agencies that are also primary data custodians. Compilers should apply standard statistical quality assurance principles and, where possible, triangulate sensitive indicators from multiple independent data sources (e.g., VMS records cross-checked against vessel logbooks and observer reports). Where data cannot be disclosed due to confidentiality or sensitivity, the indicator should be reported as "not available" with a note on the data gap, rather than suppressed without explanation. Scored assessments (METT-4, coordination scores, legal alignment scores) reflect the judgement of

DRAFT

assessors at a point in time. Governance accounts should include version tracking for scored assessments, recording assessment date, assessor identity, and any changes in scoring methodology between periods.

3.8 Worked Example: Gili Matra Marine Protected Area (Indonesia)

¶1 This section presents a worked example based on the Indonesia Gili Matra MPA pilot ocean accounts, demonstrating how governance stocks and flows indicators can be compiled and interpreted at MPA scale. Gili Matra was selected by GOAP as a primary pilot site for ocean accounting implementation [22]. The MPA comprises the islands of Gili Meno, Gili Ayer, and Gili Trawangan in West Nusa Tenggara Province, Indonesia. The pilot produced accounts for ecosystem extent, flows to the economy, flows to the environment, and ocean governance. These accounts provide one of the first empirically grounded illustrations of governance indicator compilation from ocean accounts at MPA scale. The ecosystem extent and condition accounts underlying this example were compiled following the methods described in TG-6.1 Coral Reef Ecosystem Accounting, TG-6.2 Mangrove and Coastal Wetland Accounting, and TG-6.3 Seagrass Ecosystem Accounting.

3.8.1 Context: governance stocks and biophysical account findings

¶1 The Gili Matra MPA operates under a 2014–2034 Management and Zoning Plan, which establishes the core governance stock: defined zone boundaries, legal designation as a protected area, and formally documented management responsibilities. The MPA is managed across four institutional tiers: the designated working unit (Satker), local Gili Indah Village officials, the North Lombok Regency, and the West Nusa Tenggara Provincial government. This institutional architecture spans sub-village, district, and provincial jurisdictions simultaneously [23].

¶2 Ecosystem extent accounts for the period 2015–2021 showed that despite this formal governance stock, biophysical condition deteriorated: coral reef extent decreased by 18.16 hectares and mangrove extent decreased by 7.38 hectares, whilst seagrass experienced a minor gain of 8.43 hectares. During the same period, the total measured economic value derived from the MPA's ecosystems increased substantially, from IDR 45.24 billion per year in 2015 to IDR 64.17 billion per year in 2021 – driven primarily by rising tourism demand and inflation [24].

DRAFT

3.8.2 Legal framework and governance stock indicators

¶1 **Table 2: Gili Matra Governance Stock Indicators**

Indicator	Status / Value	Notes
Management and Zoning Plan in force	Yes (2014–2034)	20-year plan; mid-term review status not confirmed
EIA coverage for MPA activities	Partial	Tourism development EIA requirements inconsistently applied
Inter-tier coordination instrument	Not formalised	4-tier institutional structure lacks a formal joint coordination agreement
IPLC co-management agreement	Not recorded	Village participation recorded in administrative role; formal co-management agreement with community rights provisions not documented in pilot accounts

¶2 The governance stock assessment reveals a pattern common in small island and coastal developing settings: a legally sound management plan exists (positive governance stock), but the institutional architecture for implementing it is fragmented across jurisdictions without a formal coordination mechanism.

3.8.3 Compliance and enforcement governance flows

¶1 The "Flows to Environment" account documented the solid waste burden generated by the growing tourism economy as a proxy indicator of governance flow adequacy. In 2021, the MPA gen-

erated 4.45 thousand tonnes of solid waste, of which 56.38% was organic. Of the total waste stream, only 25.86% was successfully recycled or managed. A further 70.4% (approximately 3,133 tonnes) accumulated in local landfills, posing an ongoing contamination threat to adjacent reef and seagrass ecosystems; the other 3.74% is not allocated in the source account [25].

¶2 Waste management performance functions as a proxy governance flow indicator: the proportion of solid waste managed to standard reflects both enforcement capacity and infrastructure investment by the responsible authorities.

¶3 **Table 3: Gili Matra Proxy Governance Flow Indicators**

Indicator	Value (2021)	Interpretation
Solid waste generated	4.45 thousand tonnes	Driven by tourism growth
Proportion organic	56.38%	Composting potential largely unrealised
Waste managed / recycled	25.86%	Major governance flow gap: 70.4% to landfill
Institutional fragmentation	4 tiers, no joint coordination body	Governance stock gap: no formal inter-tier agreement

3.8.4 MPA coverage and biophysical governance indicators

¶1 **Table 4: Gili Matra Integrated Governance and Biophysical Indicators (2015–2021)**

Indicator	2015	2021	Direction
Coral reef extent change (ha)	–	-18.16	Declining
Mangrove extent change (ha)	–	-7.38	Declining
Seagrass extent change (ha)	–	+8.43	Minor gain
Economic value (IDR billion/year)	45.24	64.17	Increasing
Waste managed to standard (%)	Not reported	25.86	Below target

3.8.5 Lessons for indicator compilation

¶1 The Gili Matra pilot illustrates several principles for MPA-scale governance indicator compilation:

1. ¶2
   Compile governance stocks and flows separately. A management plan in force is a positive stock indicator. Waste management performance at 26% is a negative flow indicator. Combining them into a single composite score would obscure this diagnosis.
2. ¶3
   Use biophysical accounts as the outcome benchmark. Governance indicator values should be interpreted against biophysical trends, rather than economic trends, when assessing whether governance is performing its conservation function.
3. ¶4
   Institutional fragmentation is a measurable governance stock indicator. The number of institutional tiers, the existence (or absence) of a formal coordination instrument, and the clarity of jurisdictional boundaries are all quantifiable and should be included in governance accounts.
4. ¶5
   Proxy indicators can substitute where direct enforcement data are absent. Where patrol records and inspection logs are not available, solid waste management rates, wastewater treatment coverage, and similar environmental outcome proxies can indicate whether governance flows are adequate.

4. Acknowledgements

DRAFT

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

5. References

1. ¶1 United Nations, Transforming our world: the 2030 Agenda for Sustainable Development, SDG Targets 14.2, 14.C, 16.6, 16.7.
2. ¶2 Adapted from Ostrom, E. (1990), *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge University Press. The definition is adapted from Ostrom's general theory of common-pool resource governance to the ocean context. See also Cicin-Sain, B. and Knecht, R.W. (1998), *Integrated Coastal and Ocean Management: Concepts and Practices*, Island Press.
3. ¶3 SEEA EA, paras 1.13–1.18, which describe the governance and institutional context for ecosystem accounting, noting that governance arrangements are relevant to understanding ecosystem management but that standardized governance accounts are not yet included in the SEEA EA compilation framework. Governance accounting for ocean systems is an emerging practice; see TG-3.7 Governance Accounts for the operational methodology.
4. ¶4 United Nations Convention on the Law of the Sea (UNCLOS), Articles 61 and 62 on conservation and utilisation of living resources of the EEZ.
5. ¶5 Kunming-Montreal Global Biodiversity Framework, Target 3: Conserve at least 30% of terrestrial, inland water, and coastal and marine areas, particularly areas of particular importance for biodiversity and ecosystem functions and services, through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures.
6. ¶6 FAO, Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines), 2015.
7. ¶7 United Nations, Global indicator framework for SDGs, Indicator 14.6.1.
8. ¶8 United Nations, Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ Agreement), adopted 19 June 2023. As of compilation date, the Agreement had not yet entered into force; ratification status should be verified at the time of indicator compilation. Key governance mechanisms include: area-based management tools for ABNJ (Part III), environmental impact assessment requirements for activities in ABNJ (Part IV), and a multilateral benefit-sharing mechanism for marine genetic resources (Part II).
9. ¶9 Global Ocean Accounts Partnership, Governance Accounts Explained. See also: SEEA EA, Section 13.5 (Accounting for the Ocean, global consultation draft), which introduces the distinction between institutional architecture (stocks) and activities and transactions (flows) within ocean governance accounts. Available at: https://oceanaccounts.org/insights/governance-accounts-explained/ (https://oceanaccounts.org/insights/governance-accounts-explained/)
0. ¶10 FAO, Code of Conduct for Responsible Fisheries, 1995, Articles 6-12 on fisheries management.
1. ¶11 United Nations, Global indicator framework for SDGs, Indicator 14.C.1 and associated metadata.
2. ¶12 FAO, Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA), 2016.
3. ¶13 World Bank, Worldwide Governance Indicators, 2025 Methodology Revision. The WGI aggregates data from over 35 cross-country sources using an Unobserved Components Model (UCM), producing annual composite indicators on a 0–100 absolute scale for six governance dimensions. Available at: https://www.worldbank.org/en/publication/worldwide-governance-indicators (https://www.worldbank.org/en/publication/worldwide-governance-indicators).
4. ¶14 Hockings, M. et al. (2019), METT-4, p. 12 on the six elements of the management effectiveness evaluation framework.
5. ¶15 Balmford, A. et al. (2004), The worldwide costs of marine protected areas, *Proceedings of the National Academy of Sciences*, 101(26), 9694–9697. See also McCarthy, D.P. et al. (2012), Financial costs of meeting global biodiversity conservation targets, *Science*, 338(6109), 946–949; and Waldron, A. et al. (2020), Protecting 30% of the planet for nature: costs, benefits and economic implications, Campaign for Nature. Cost benchmarks vary significantly by location and should be applied with reference to national cost data where available.
6. ¶16 Spillover index methodology follows Halpern, B.S. and Warner, R.R. (2002), Marine reserves have rapid and lasting effects, *Ecology Letters*, 5(3), 361–366; and Goni, R. et al. (2010), Net contribution of spillover from a marine reserve to fishery catches, *Marine Ecology Progress Series*, 400, 233–243. Measurement requires paired survey data inside and outside MPA boundaries collected under consistent protocols.
7. ¶17 United Nations, Global indicator framework for SDGs, Indicator 14.b.1 and SSF Guidelines national plan implementation metadata.
8. ¶18 Davies, S. and Rangeley, R. (2010), Connecting with fisheries: Developing observer programmes in developing countries, *Marine Policy*, 34(6), 1118–1127. See also Western and Central Pacific Fisheries Commission (WCPFC), Conservation and Management Measure 2019-02 on observers; and Kinney, M.J. et al. (2021), Observer coverage targets for monitoring fishing activities, *ICES Journal of Marine Science*, for updated guidance on appropriate coverage rates by fishery type.

DRAFT

9. ¶19 Drakopulos, L. et al. (2022), Making global oceans governance (in)visible with smart earth: The case of Global Fishing Watch. Satellite-based AIS monitoring and dark vessel detection are described as emerging proxy governance indicators for enforcement coverage in Areas Beyond National Jurisdiction and large EEZs where patrol capacity is limited.
0. ¶20 FAO, Voluntary Guidelines for Flag State Performance, 2014, para 32 on port state control cooperation.
1. ¶21 United Nations Division for Ocean Affairs and the Law of the Sea (DOALOS), SDG 14.C.1 Voluntary National Reporting Tool, 2022. Available at: https://unstats.un.org/sdgs/metadata/files/Metadata-14-0c-01.pdf (https://unstats.un.org/sdgs/metadata/files/Metadata-14-0c-01.pdf) (accessed 2026) — the DOALOS SDG 14.C.1 metadata document, which sets out the seven implementation dimensions and the voluntary national reporting questionnaire. DOALOS itself: https://www.un.org/depts/los/index.htm (https://www.un.org/depts/los/index.htm).
2. ¶22 Global Ocean Accounts Partnership / SEEA, Ocean Accounts of Gili Meno, Ayer, Trawangan (Gili Matra) of Indonesia, 2022. Available at: https://webunwto.s3.eu-west-1.amazonaws.com/s3fs-public/2023-12/Indonesia_Pilot_Ocean_Accounts_Report.pdf (https://webunwto.s3.eu-west-1.amazonaws.com/s3fs-public/2023-12/Indonesia_Pilot_Ocean_Accounts_Report.pdf)
3. ¶23 Ocean Accounts of Indonesia, pilot report, 2023. The four-tier institutional structure is described in the governance accounts section of the Gili Matra pilot. Available at: https://webunwto.s3.eu-west-1.amazonaws.com/s3fs-public/2023-12/Indonesia_Pilot_Ocean_Accounts_Report.pdf (https://webunwto.s3.eu-west-1.amazonaws.com/s3fs-public/2023-12/Indonesia_Pilot_Ocean_Accounts_Report.pdf)
4. ¶24 Ocean Accounts of Gili Matra (2022), ecosystem extent and economic valuation results. Economic value increase from IDR 45.24 billion/year (2015) to IDR 64.17 billion/year (2021) is attributed primarily to inflation, higher real interest rates, and intensifying tourism demand; see also Ocean Accounts of Indonesia (2023).
5. ¶25 Ocean Accounts of Gili Matra (2022), Flows to Environment account: solid waste. Total waste generated: 4.45 thousand tonnes (2021); organic fraction: 56.38%; recycled/managed: 25.86%; accumulated in landfill: 70.4% (approximately 3,133 tonnes; 70.4% × 4,450 tonnes). Note: 25.86% + 70.4% = 96.26%; the unallocated residual (3.74%) reflects source data categorisation in the pilot accounts and does not affect the governance flow indicator values. See also: Ocean Accounts of Indonesia (2023), perikanan.org edition.

DRAFT

Asset Accounts

Builds asset accounts for ocean resources — the structured records that track what you have, what you gained, what you lost, and what remains.

Version 0.9.1 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

OUTCOME

After working through this Circular, you will be able to build asset accounts for ocean resources — the structured records that track what you have, what you gained, what you lost, and what remains. These capabilities connect directly to the budget processes described in TG-1.1 OA and National Budget Processes, where asset accounts provide the evidence base for allocating public resources to ocean conservation and sustainable use. They also underpin the depletion-adjusted income measures that indicate whether economic growth is coming at the expense of natural capital.

Section 3.5.3 additionally specifies the choices that govern any net present value valuation of an ecosystem asset — perpetuity against finite horizon, and the functional form linking a change in condition to a change in service capacity — together with ecosystem degradation, damage cost, and the offset requirement and restoration equivalence unit that no-net-loss policies rest on. Those specifications are normative for the publication; the service-level valuation methods they discount are in TG-2.4 Environmental (including Ecosystem) Goods and Services Section 3.10.

Ocean accounts answer to two disciplines at once. Accounting requires that numbers balance, whilst ecology describes fish populations whose dynamics resist neat categorisation. This Circular sets out how to satisfy both: maintaining the accounting identities that ensure internal consistency whilst respecting the ecological behaviour of marine systems.

DRAFT

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 3
3.1 Physical Asset Accounts 3
3.2 Compilation Procedure for Asset Accounts 5
3.3 Monetary Asset Accounts 8
3.4 Individual Environmental Assets 9
3.5 Ecosystem Assets 12
3.6 Produced Assets in the Ocean Domain 22
3.7 Worked Example: Coastal Ecosystem Asset Accounts 22
Implementation Considerations 26
4. Acknowledgements 26
Footnotes 26

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Asset Accounts (2026) (GOAP Technical Guidance on Ocean Accounting, TG-3.1, v0.9.1). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-3/3-1-assets/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

1. Outcome

¶1 After working through this Circular, you will be able to build asset accounts for ocean resources — the structured records that track what you have, what you gained, what you lost, and what remains. These capabilities connect directly to the budget processes described in **TG-1.1 OA and National Budget Processes**, where asset accounts provide the evidence base for allocating public resources to ocean conservation and sustainable use. They also underpin the depletion-adjusted income measures that indicate whether economic growth is coming at the expense of natural capital.

¶2 Section 3.5.3 additionally specifies the choices that govern any net present value valuation of an ecosystem asset — perpetuity against finite horizon, and the functional form linking a change in condition to a change in service capacity — together with ecosystem degradation, damage cost, and the offset requirement and restoration equivalence unit that no-net-loss policies rest on. Those specifications are normative for the publication; the service-level valuation methods they discount are in **TG-2.4 Environmental (including Ecosystem) Goods and Services** Section 3.10.

¶3 Ocean accounts answer to two disciplines at once. Accounting requires that numbers balance, whilst ecology describes fish populations whose dynamics resist neat categorisation. This Circular sets out how to satisfy both: maintaining the accounting identities that ensure internal consistency whilst respecting the ecological behaviour of marine systems.

2. Requirements

¶1 **Essential prerequisites:**

- ¶2 **TG-0.1 General Introduction to Ocean Accounts**: conceptual framework and domain structure
- ¶3 **TG-0.2 Overview of Relevant Statistical Standards**: SNA/SEEA accounting architecture

¶4 **Helpful background:**

- ¶5 **TG-0.7 Quality Assurance Principles**: data quality and uncertainty management

¶6 **Framework Position**

¶7 This Circular addresses the stock side of the Ocean Accounts Framework — asset accounts that record the state of marine and coastal assets across all three stock domain groups. SNA produced assets (SG1) are subject to capital formation and depreciation through economic flows (E3). Environmental assets (SG3) supply ecosystem services to the economy (E9) and support intermediate ecological processes (E11). In the Ocean Accounts Framework (TG-0.1 Figure 0.1.2):

Edge	Direction	Description
E3	FG1 ↔ SG1	Economic flows interacting with SNA assets (Applied)
E9	SG3 → FG1	Environmental assets supplying ecosystem services to economy (Applied)
E11	FG3 ↔ SG3	Environmental assets supporting intermediate ecosystem services (Applied)

¶8 **Scope.** TG-3.1 owns the asset account tables — physical and monetary, individual environmental assets and ecosystem assets — their rows, columns and accounting identities, and the compilation procedure that populates them. It cross-refers for the sector-specific method that produces an entry: fisheries stock assessment and sustainable yield to **TG-6.7**, aquaculture to **TG-3.9** and **TG-6.8**, offshore energy to **TG-3.10** and **TG-6.9**, pelagic delineation to **TG-6.5**; for the measurement of the variables it records to Section 4, in particular **TG-4.1** for extent and **TG-4.8** and **TG-4.9** for condition; and for the service-level valuation methods its NPV calculations discount to **TG-2.4** Section 3.10.

DRAFT

3. Guidance Material

¶1 Asset accounts record what you hold and what you have used. They give the stock of marine assets at the beginning and end of an accounting period and every change in between — growth, extraction, natural losses, discoveries, and measurement revisions[1]. This structured bookkeeping allows the central question to be answered: whether ocean capital is being drawn down faster than it regenerates.

¶2 Two complementary accounting frameworks apply to ocean assets. The SEEA Central Framework provides the methodology for accounting for individual environmental assets — fish stocks, seabed minerals, water resources — each tracked separately. SEEA Ecosystem Accounting extends this by treating ecosystems as integrated spatial units: a coral reef or seagrass meadow as a whole rather than only the fish or carbon within it. For ocean accounting, you will typically need both. The individual asset approach records how many tonnes of fish remain, whilst the ecosystem asset approach records whether the reef that supports those fish is expanding or contracting.

¶3 This section examines the structure and accounting entries for physical and monetary asset accounts, before addressing the specific requirements for individual environmental assets (Section 3.4), ecosystem assets (Section 3.5), and produced assets in the ocean domain (Section 3.6). Section 3.2 provides a compilation procedure detailing the steps from data collection to account entry, whilst Section 3.7 presents a worked example with synthetic data demonstrating how to populate asset accounts for a hypothetical coastal area. The methodology presented here provides the basis for the thematic circulars on coral reef accounts (**TG-6.1**), mangrove and wetland accounts (**TG-6.2**), and seagrass accounts (**TG-6.3**).

3.1 Physical Asset Accounts

¶1 Physical asset accounts are where you count what you have in tangible units — tonnes of fish, hectares of seagrass, cubic metres of sand. They record whether marine resources are growing or shrinking in physical terms, before any monetary valuation is applied[2]. This matters because price changes can mask physical depletion: a fish stock can be worth more in dollar terms even as the population collapses, since scarcity drives up prices. Physical accounts separate the volume change from the price change.

Basic structure

¶1 Every physical asset account follows the same logic [3]:

1. ¶2 **Opening stock** — what you had at the start of the year
2. ¶3 **Additions to stock** — everything that increased the stock during the year, including natural growth, discoveries, upward reappraisals, and reclassifications
3. ¶4 **Reductions in stock** — everything that decreased the stock, including extractions, natural losses, catastrophic losses, downward reappraisals, and reclassifications
4. ¶5 **Closing stock** — what you have at the end of the year

¶6 The closing stock must equal the opening stock plus total additions minus total reductions. If it does not balance, something is missing from your records — unreported catch, an unobserved storm event, or a measurement error. This accounting identity is your quality control mechanism: it forces you to account for every change (Figure 3.1.1).

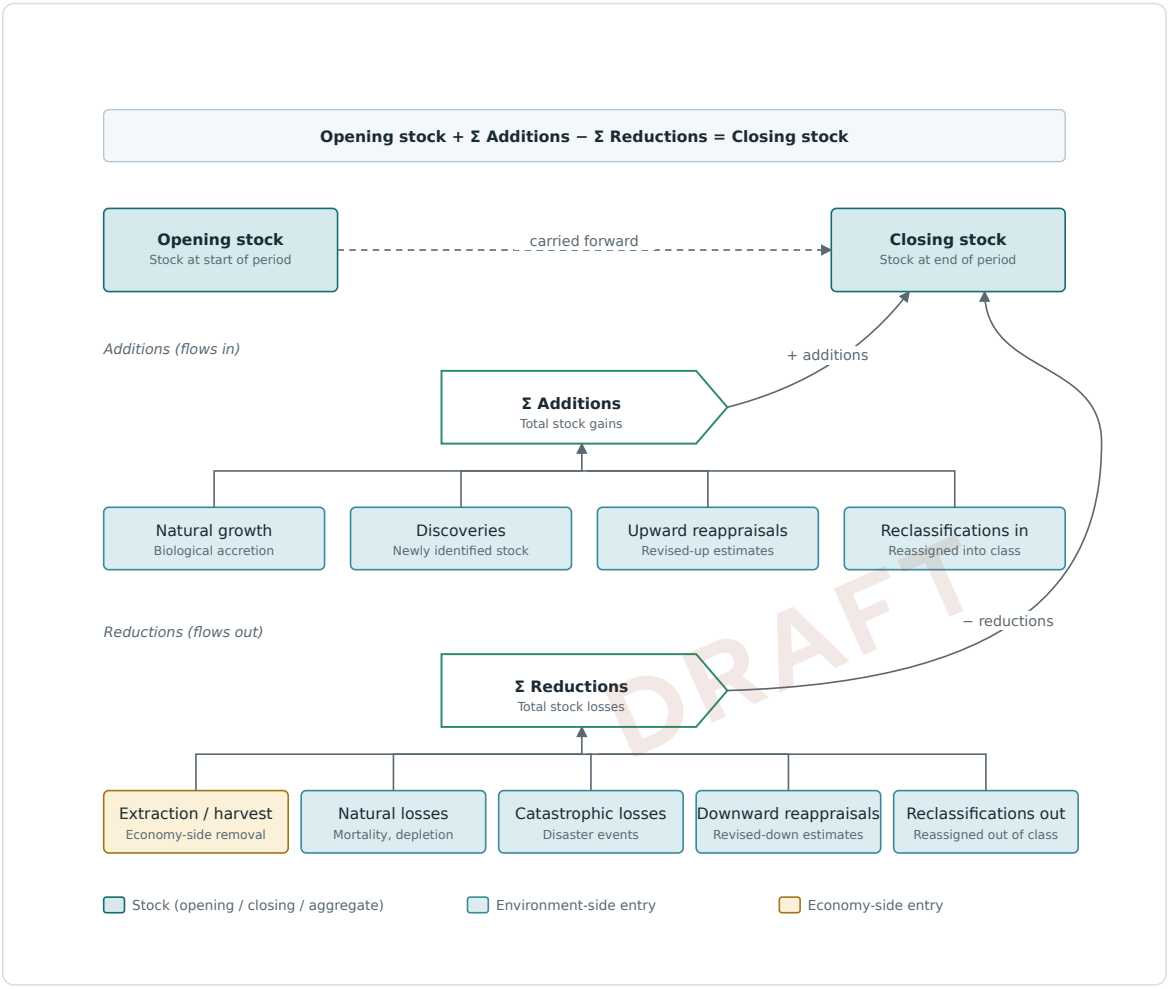


Figure 3.1.1 SEEA Central Framework environmental-asset accounts follow one stock-flow identity: opening stock plus additions minus reductions equals closing stock. Extraction/harvest is the only economy-side reduction; contrast the ecosystem extent account in Figure 3.1.2.
Source: SEEA CF Table 5.2 (physical asset account structure by type of asset); SEEA CF paras 5.43–5.46; TG-3.1.
Adapted from: SEEA CF Table 5.2, recast as a stock-flow identity diagram for TG-3.1.

Additions to stock

¶1 **Natural growth** is the primary addition for renewable resources like fish stocks. It encompasses recruitment — new fish joining the stock — and biomass increase as existing individuals grow [4]. Natural growth is driven by biological processes that vary with environmental conditions, stock size, and species characteristics. For a fisheries manager, natural growth sets the sustainable harvest ceiling: the largest catch that can be taken without reducing the stock's long-term productivity [5]. An accurate measure of natural growth therefore allows harvest limits to be set that keep the stock stable.

¶2 **Discoveries** apply primarily to non-renewable resources. In ocean accounting, this means identification of new oil and gas deposits, seabed mineral resources such as polymetallic nodules and seafloor massive sulphides, and rare earth elements in marine sediments [6]. Discoveries can also apply to aquatic resources when previously unknown fish stocks are identified and assessed — though this is rare in well-surveyed waters.

¶3 **Upward reappraisals** record cases where the estimate of stock size increased but the stock itself did not physically change [7]. The distinction separates a real change in the ocean from an improvement in measurement. For fish stocks, a reappraisal occurs when a stock assessment model is updated with new data and produces a revised biomass estimate. The SEEA CF acknowledges that for fish stocks, "it may not be possible to attribute the changes to natural causes or harvesting activity" and in such cases "only a

regional or national aggregate resource value will be produced"[8]. Compilers should therefore document whether a stock change reflects biological dynamics or improved measurement, even where the boundary between the two is indistinct.

¶4 **Reclassifications** record transfers between asset categories without any physical change[9]. A common ocean example: when a wild fish stock becomes subject to aquaculture operations, it transfers from natural aquatic resources to cultivated aquatic resources. The SEEA CF emphasises that "in cases where stocking with cultured seeds is regularly conducted, as commonly observed in freshwater resources, it is important to include the amount of released seeds as a reclassification from cultivated aquatic resources"[10]. Misclassification matters for policy: it can make wild stocks appear to be growing when they are in fact being supplemented by hatchery production.

Reductions in stock

¶1 **Extraction** (or harvest, for biological resources) is the removal of natural resources for use in economic activity[11]. For fish stocks, extraction corresponds to gross catch — the total live weight of fish caught, including discarded catch but excluding pre-catch losses[12]. Countries use gross catch rather than landings because discards still remove fish from the ocean, even though they never reach port. The FAO defines the stages of catch as[13]:

- ¶2 *Gross removal*: total live weight of fish caught or killed during fishing operations
- ¶3 *Gross catch*: gross removal less pre-catch losses
- ¶4 *Retained catch*: gross catch less discarded catch
- ¶5 *Landings*: net weight of quantities landed at port
- ¶6 *Nominal catch*: live weight equivalent of landings

¶7 **Normal losses** (natural mortality for biological resources) are decreases from natural processes — death from age, predation, disease, and accidents[14]. For fish stocks, natural mortality is a key parameter in stock assessment models. It must be estimated alongside fishing mortality to understand population dynamics, because a stock with high natural mortality can tolerate less fishing pressure than one where most individuals die of old age.

¶8 **Catastrophic losses** are "exceptional and significant reductions in the natural resource"[15] due to discrete events — storms, disease outbreaks, toxic algal blooms, mass coral bleaching, or oil spills. The distinction from normal losses matters for two reasons. First, if catastrophic losses are increasing in frequency, that is a warning sign that environmental conditions are deteriorating. Second, catastrophic losses are unpredictable and fall outside the scope of normal management, so they need to be tracked separately to avoid distorting assessments of whether routine management is working.

¶9 **Downward reappraisals** and **reclassifications** mirror their counterparts in additions, recording accounting adjustments from improved information or transfers between categories.

Depletion

¶1 Depletion is the central sustainability signal in the asset account. It records whether a renewable resource is being harvested faster than it can regenerate, and by how much. For a policy-maker, depletion answers whether current consumption is drawing down the productive base itself.

¶2 For renewable resources, depletion occurs when "the extraction of the natural resource is occurring at a level greater than that of regeneration"[16]. The formula is straightforward:

> *Depletion = max(0, Extraction - Sustainable yield)*

¶3 When extraction stays at or below sustainable yield, depletion is zero — the stock can absorb the harvest. When extraction exceeds sustainable yield, every tonne above that threshold is depletion — a reduction in the stock's future productive capacity[17]. For non-renewable resources such as mineral deposits, there is no regeneration, so depletion equals extraction: every barrel of offshore oil extracted is permanently removed from the stock.

¶4 Depletion links the physical and monetary accounts. In the 2025 SNA, depletion of natural resources is treated as a cost of production analogous to depreciation of produced assets, reducing net measures of income and product[18]. A country reporting high GDP from fisheries alongside high depletion is therefore overstating its true income, since part of what appears as earnings is the liquidation of natural capital. The SEEA CF notes that "since the drivers for changes in populations of aquatic resources can only be modelled, it may be difficult to obtain precise and consistent measures of sustainable yield over time"[19]. For methodological guidance on estimating sustainable yield and depletion for fisheries, see **TG-6.7 Fisheries Accounting: Integrating Stock Assessment**.

3.2 Compilation Procedure for Asset Accounts

¶1 This section walks through the step-by-step procedure for compiling ocean asset accounts, beginning with the assembly of raw data and ending with balanced accounts that integrate with the broader national accounting system. Following these steps ensures that your accounts are internally consistent and comparable across asset types.

Step 1: Data collection and source identification

¶1 Start by identifying the data sources you need for each asset type. Different marine assets draw on distinct data sources:

¶2 **For individual environmental assets** (fish stocks, seabed minerals):

- ¶3 **Stock assessment reports** from fisheries management agencies, providing estimates of spawning stock biomass, recruitment, natural mortality, and fishing mortality (see **TG-6.7 Fisheries Accounting: Integrating Stock Assessment**)
- ¶4 **Geological surveys and commercial exploration reports** for mineral and energy resources, including estimates of proven reserves and probabilistic resource classifications (see **TG-3.10 Offshore Energy Accounts**)

DRAFT

- ¶5 **Catch statistics** from fisheries agencies and international databases (FAO FishStatJ), recording landings, gross catch, and discards by species and fishing zone

¶6 **For ecosystem assets** (coral reefs, seagrass meadows, mangroves):

- ¶7 **Remote sensing imagery** (Sentinel-2, Landsat, MODIS) processed to classify ecosystem extent and detect changes over time (see **TG-4.1 Remote Sensing and Geospatial Data**)
- ¶8 **Field survey data** from ecological monitoring programmes, providing measurements of ecosystem condition variables such as coral cover, seagrass shoot density, mangrove canopy height, and water quality parameters (see **TG-4.2 Survey Methods for Ocean Economic Activity**)
- ¶9 **National spatial databases** delineating protected areas, coastal zone boundaries, and ecosystem type classifications consistent with the IUCN Global Ecosystem Typology

¶10 Assess data quality following **TG-0.7 Quality Assurance Principles**. Pay particular attention to three things: temporal consistency (are opening and closing stocks measured on a comparable basis?), spatial coverage (do the data cover the full accounting area?), and measurement uncertainty (what are the confidence intervals, and are they documented?).

Step 2: Classification and mapping to asset categories

¶1 Next, map your source data to the asset classification system used in the accounts. Getting this right matters because it determines how your numbers aggregate and compare with other countries. The SEEA CF classifies environmental assets into major categories including aquatic resources, mineral and energy resources, water resources, timber resources, land, and soil resources [20]. For ocean accounting, the relevant categories are:

- ¶2 **Natural aquatic resources** (wild fish, shellfish, and other uncultivated aquatic organisms)
- ¶3 **Cultivated aquatic resources** (farmed fish, shellfish, and seaweed)
- ¶4 **Mineral and energy resources** (offshore oil and gas, seabed minerals, marine aggregates)
- ¶5 **Water resources** (coastal aquifers subject to saltwater intrusion, and seawater abstraction is recorded as an abiotic flow rather than an asset stock)

¶6 SEEA EA ecosystem assets are classified using the IUCN Global Ecosystem Typology. Table 3.2.1 below summarises the marine ecosystem types.

IUCN GET code	Ecosystem types covered
M1 Marine Shelf	Seagrass meadows, kelp forests, coral reefs, shellfish beds, subtidal rocky reefs.
M2 Pelagic Ocean Waters	Epipelagic, mesopelagic, bathypelagic zones.
M3 Deep Sea Floors	Abyssal plains, submarine canyons, hydrothermal vents.
MFT Brackish Tidal Systems	Mangroves, saltmarshes, coastal brackish lagoons.
MT Shorelines	Rocky shores, sandy beaches.

DRAFT

¶7 If your country uses a national ecosystem type classification that differs from the IUCN GET, document the correspondence between the two. This ensures that your ecosystem extent can be aggregated to standard categories for international comparison.

Step 3: Measurement and quantification

¶1 With data sources identified and classifications established, you can quantify opening stocks, additions, reductions, and closing stocks in physical units appropriate to each asset type.

¶2 For **fish stocks**, stock assessment models provide estimates of total biomass (or spawning stock biomass) at the beginning of the accounting period (opening stock). Natural growth is estimated from recruitment models and individual growth rates. Extraction is measured as gross catch from fisheries statistics. Natural mortality is estimated from stock assessment parameters. The accounting identity (opening stock + growth - mortality - catch = closing stock) serves as your reconciliation tool. Where stock assessment provides direct estimates of both opening and closing stock, the identity becomes a consistency check, and discrepancies may indicate data errors or unobserved changes requiring reappraisal entries.

¶3 For **ecosystem extent**, remote sensing analysis provides the primary measurement of opening and closing extent, typically expressed in hectares or square kilometres. Change detection algorithms identify areas where ecosystem type has changed (conversions), distinguishing managed changes (restoration, conversion to aquaculture) from natural changes (storm damage, succession). Ground-truthing surveys validate remotely sensed classifications and provide confidence ratings. The SEEA EA recommends recording extent changes in a structured account showing managed expansion, natural expansion, managed reduction, and natural reduction separately [21].

¶4 For **ecosystem condition**, the measurement process involves selecting condition variables for each ecosystem type following the SEEA EA Ecosystem Condition Typology (ECT), measuring variable values from field surveys or remote sensing, and normalising these values into indicators relative to reference conditions. Condition accounts record the raw variable values rather than derived indicators, whilst the indicator derivation is addressed in **TG-2.1 Aggregate Biophysical Indicators of Environmental State**.

Step 4: Account entry and balancing

¶1 Once physical quantities have been measured, enter them into the asset account structure. The account must balance: closing stock = opening stock + total additions - total reductions. Any imbalance signals an error — either a data fault or a missing entry (unreported extraction, unobserved natural changes, or a needed reappraisal adjustment).

¶2 For marine assets, three issues require particular attention:

- ¶3 **Spatial boundaries**: Ensure that opening and closing stocks cover the same geographic area. If jurisdictional boundaries or accounting area definitions changed during the period, record those changes as reclassifications rather than real changes.

Otherwise, you will attribute administrative decisions to ecological processes.

- ¶4 **Unit consistency**: Keep all entries for a given asset in the same measurement unit. For fish stocks, this typically requires converting landings (wet weight) to live weight equivalent, and converting different life stages to a common biomass measure.
- ¶5 **Temporal alignment**: Ensure all entries refer to the same accounting period. Where stock assessments use different time periods or reference dates than the calendar year accounting period, adjustments may be needed.

Step 5: Monetary valuation (for monetary accounts)

¶1 For monetary asset accounts, you translate physical stock quantities into monetary values. This is the step where accounting and ecology are most in tension, since pricing a fish stock or a mangrove forest requires assumptions about a future that ecology renders uncertain.

¶2 For fish stocks and other renewable natural resources, the net present value (NPV) of expected future resource rents provides the standard valuation approach[22]. The NPV calculation requires:

1. ¶3 **Resource rent estimation**: Calculate the annual resource rent as the difference between the value of harvest and all costs (including labour, capital, intermediate inputs, and normal return on produced assets). This isolates the economic surplus that the natural resource itself contributes.
2. ¶4 **Discount rate selection**: Determine an appropriate discount rate reflecting the time value of money and asset-specific risk factors (see **TG-1.9 Safe Usage of Monetary Valuation** for detailed guidance). Higher discount rates reduce asset values, so this choice matters for policy.
3. ¶5 **Asset life assumption**: Estimate the expected duration of the resource rent stream. For sustainably managed renewable resources, this may be assumed to be perpetual.

¶6 For ecosystem assets, the monetary value is estimated as the NPV of expected future ecosystem service flows. This requires:

1. ¶7 **Service quantification**: Measure the physical supply of ecosystem services from the asset (see **TG-3.2 Flows from Environment to Economy**)
2. ¶8 **Service valuation**: Apply appropriate valuation methods to estimate unit prices for each ecosystem service
3. ¶9 **NPV calculation**: Discount the stream of future service values to present value

¶10 Changes in monetary value are decomposed into three components:

- ¶11 Changes due to physical volume changes (additions and reductions in stock)
- ¶12 Changes due to updated expectations about future rents or service flows (reappraisals)
- ¶13 Changes due to price movements (revaluations)

¶14 This decomposition matters because it prevents price effects from masking physical depletion. A fish stock can be worth more in dollar terms this year than last, even as the population declines, provided prices rose enough. Separating the two effects keeps the monetary account aligned with the underlying physical change.

Step 6: Integration with balance sheets and other accounts

¶1 The final step is integrating asset accounts with national balance sheets and with other ocean accounts. The balance sheet presents the stock of all assets (produced assets, non-produced natural assets, ecosystem assets, financial assets) and liabilities at a single point in time, enabling calculation of net worth[23]. Changes in net worth during the accounting period are explained by saving, capital transfers, and holding gains/losses recorded in the revaluation account.

¶2 For ocean accounting, integration ensures that:

- ¶3 **Depletion entries** in asset accounts correspond to depletion costs in production accounts and adjustments to net domestic product
- ¶4 **Extraction entries** in asset accounts correspond to natural resource inputs in physical supply-use tables (**TG-3.2 Flows from Environment to Economy**)
- ¶5 **Ecosystem service flows** are consistent with the capacity to supply services implied by ecosystem extent and condition (as illustrated in the worked example below)
- ¶6 **Investment in ocean infrastructure** (such as aquaculture facilities and offshore energy) is recorded as gross fixed capital formation in produced assets, enabling joint analysis of natural and produced capital stocks

¶7 Cross-stack connections upward to policy circulars include:

- ¶8 **TG-1.1 National Ocean Budgets** uses asset values and depletion estimates to inform natural capital budgeting
- ¶9 **TG-2.1 Aggregate Biophysical Indicators of Environmental State** derives extent change indicators and condition indices from asset accounts
- ¶10 **TG-2.2 Productivity Indicators** uses fish stock biomass and sustainable yield estimates to calculate indicators of resource productivity

¶11 Cross-stack connections downward to data circulars include:

- ¶12 **TG-4.1 Remote Sensing and Geospatial Data** provides methods for extent mapping that populate ecosystem extent accounts
- ¶13 **TG-4.2 Survey Methods for Ocean Economic Activity** provides protocols for condition variable measurement
- ¶14 **TG-4.3 Administrative Data Sources** provides the spatial framework for delineating ecosystem assets and aggregating data

¶15 Asset accounts therefore operate as an integrated component of the broader ocean accounting system rather than a standalone exercise.

DRAFT

3.3 Monetary Asset Accounts

¶1 Monetary asset accounts translate the physical stocks and changes described in Section 3.1 into economic values. This translation enables three things that physical accounts alone cannot do: aggregate across different asset types (you cannot add tonnes of fish to hectares of seagrass, but you can add their monetary values), compare environmental assets with produced and financial assets on common terms, and calculate depletion-adjusted income measures that reveal whether economic growth is genuine or is partly the liquidation of natural capital [24]. For detailed guidance on valuation methods applicable to ocean assets, see **TG-1.9 Safe Usage of Monetary Valuation**.

Structure of monetary asset accounts

¶1 The structure parallels physical accounts, with one important addition – a revaluation entry [25]:

1. ¶2 **Opening stock value** – the monetary value of the asset at the beginning of the accounting period
2. ¶3 **Additions to stock value** – value of growth, discoveries, and upward reappraisals
3. ¶4 **Reductions in stock value** – value of extractions, normal losses, catastrophic losses, and downward reappraisals
4. ¶5 **Revaluations** – changes in value due to price changes, distinct from physical changes
5. ¶6 **Closing stock value** – the monetary value at the end of the accounting period

¶7 The revaluation entry captures holding gains and losses – changes in asset value attributable to changes in prices rather than physical quantities [26]. This separation is essential: without it, a rise in asset value cannot be attributed to an improvement in the ecosystem rather than a shift in market prices.

Valuation approaches

¶1 Environmental assets are typically not traded in markets, so no observable price exists. The SEEA CF describes several approaches to address this [27]:

¶2 **Net present value (NPV)** is the preferred approach for valuing natural resources. You estimate the stream of expected future resource rents – the economic surplus accruing to the resource owner after all costs and normal returns are deducted – and discount this stream to the present [28]. For natural resources:

> *Value = Resource rent x Discount factor*

¶3 where the discount factor adjusts for the time value of money and the expected duration of the income stream. The SEEA CF describes the discount factor (Omega) as linking "future resource rents to the present value of the asset" [29]. Key considerations for discount rate selection include the real rate of interest, expected asset life, and country-specific factors [30].

¶4 Discount rate selection can affect asset valuations substantially, particularly for long-lived assets such as fish stocks under perpetual management regimes. A lower discount rate makes long-term sustainability more economically visible, whilst a higher rate assigns less weight to the distant future. The SEEA CF provides extensive guidance on discount rate methodology in Annex A5.2, covering asset life assumptions, risk adjustments, and country-specific factors [31]. For detailed guidance on discount rate selection and its implications for marine asset valuation, see **TG-1.9 Safe Usage of Monetary Valuation**.

¶5 **Market prices** may be used where environmental assets or rights to extract them are traded. For aquatic resources, long-term fishing licences and individual transferable quotas (ITQs) may provide market-based valuations [32]. Markets for environmental assets are, however, often thin or non-existent, and the approach therefore has limited applicability. The SEEA CF notes that "in many cases, where the government hands the access rights to fishermen, trading in these access rights is prohibited and there is therefore no directly observable market valuation" [33].

Deriving resource rent for a wild-capture fishery

¶6 **Resource rent per tonne.** Resource rent is the surplus remaining after deducting all costs of fishing from the gross value of catch. It is estimated as:

¶7

$$\text{Resource rent per tonne} = \frac{\text{Gross value of landings} - (\text{Operating costs} + \text{Depreciation} + \text{Normal return to capital})}{\text{Total catch (tonnes)}}$$

¶8 Normal return to capital is estimated as the risk-free rate applied to the replacement value of the fishing fleet (SEEA CF para 5.114).

¶9 If gross value of landings is USD 28.8 million (24,000 tonnes at USD 1,200 per tonne average price), and total fishing costs are USD 18 million (including labour, fuel, vessel depreciation, normal return to capital), resource rent is USD 10.8 million. Resource rent per tonne is USD 10.8 million / 24,000 tonnes = USD 450 per tonne.

¶10 The rent estimated here is the **total** rent generated by the fishery, only part of which accrues to government as access payments or royalties. Where those receipts are also compiled in the governance revenue tables (**TG-3.7** Table 3.7.10b), the two must be reconciled rather than added; presenting government rent receipts alongside a depletion-adjusted net income measure without reconciliation double counts the same flow. The budget use of the resulting figure is in **TG-1.1** Section 3.4.

¶11 **Restoration cost** approaches estimate the cost of restoring an ecosystem asset to a reference condition. This approach is described in SEEA EA as a complement to NPV-based valuation, particularly for ecosystem degradation [34]. It answers a different question: the cost of replacing what has been lost, which is distinct from the worth of the ecosystem itself. See **TG-1.9 Safe Usage of Monetary Valuation** for detailed comparison of valuation approaches.

DRAFT

Structural template — monetary asset account

¶1 Table 1b is the blank counterpart to the physical templates in Section 3.4, for individual environmental assets in monetary terms. The revaluation row is what distinguishes it from the physical account and is the row most often omitted; without it a price movement is indistinguishable from a change in the resource.

¶2 **Table 1b: Monetary asset account — structural template (after SEEA CF Table 5.17)**

Accounting entry	Asset class 1	Asset class 2	…	Total
Opening stock value	[value]	[value]	…	[Σ]
Additions to stock value				
— Growth in stock	[value]	[value]	…	[Σ]
— Discoveries	[value]	[value]	…	[Σ]
— Upward reappraisals	[value]	[value]	…	[Σ]
— Reclassifications in	[value]	[value]	…	[Σ]
Total additions	[Σ]	[Σ]	…	[ΣΣ]
Reductions in stock value				
— Extraction	[value]	[value]	…	[Σ]
— Normal losses	[value]	[value]	…	[Σ]
— Catastrophic losses	[value]	[value]	…	[Σ]
— Downward reappraisals	[value]	[value]	…	[Σ]
— Reclassifications out	[value]	[value]	…	[Σ]
Total reductions	[Σ]	[Σ]	…	[ΣΣ]
Revaluation (price change only)	[+/-]	[+/-]	…	[+/-]
Net change in value	[+/-]	[+/-]	…	[+/-]
Closing stock value	[value]	[value]	…	[Σ]
Memorandum: depletion at constant prices	[value]	[value]	…	[Σ]

¶3 *Table 1b: Structural template of a monetary asset account. The identity is Closing = Opening + total additions − total reductions + revaluation. The memorandum line carries depletion valued at the average of opening and closing prices, which is the figure adjusted income measures deduct; it is a memorandum rather than an account entry because its value is already inside the reduction rows.*

Valuation of depletion

¶1 The monetary value of depletion is calculated by multiplying physical depletion by the appropriate asset price[35]. Following the conventions in the SNA and SEEA CF, depletion should be valued at the average of opening and closing prices:

> *Monetary depletion = Physical depletion x (P_opening + P_closing) / 2*

DRAFT

¶2 This mid-period valuation "is consistent with the rules in the SNA for the valuation of consumption of fixed capital"[36]: depletion of a fish stock is treated on the same footing as depreciation of a factory. Both represent the using-up of productive capacity, and both should be deducted from income.

3.4 Individual Environmental Assets

¶1 Individual environmental assets are "those environmental assets that may provide resources for use in economic activity"[37] — the specific natural resources that can be named and counted, such as fish stocks, oil deposits, and sand reserves. For ocean accounting, the principal categories include aquatic resources (Section 3.4.1), mineral and energy resources (Section 3.4.2), and water resources (Section 3.4.3).

3.4.1 Aquatic resources

¶1 **Aquatic resources** include fish, crustaceans, molluscs, shellfish and other aquatic organisms such as sponges and seaweed, as well as aquatic mammals such as whales[38]. These organisms are subject to harvest for commercial, subsistence, and recreational purposes. The SEEA CF distinguishes between:

- ¶2 **Natural aquatic resources** — wild fish and other aquatic organisms not under direct cultivation
- ¶3 **Cultivated aquatic resources** — organisms raised in aquaculture facilities, including fish, shellfish, seaweed, and other species

¶4 This distinction determines how the assets are classified in the accounts: natural aquatic resources are non-produced assets (nature made them), whilst cultivated aquatic resources are produced assets (fixed assets for breeding stocks, and inventories for stocks held for sale)[39]. The distinction matters for policy because the management interventions differ: a wild fishery is managed by controlling extraction, whereas aquaculture is managed by controlling production inputs. Detailed guidance on aquaculture accounting is provided in **TG-3.9 Aquaculture Accounts**.

¶5 **What the asset account requires of a stock assessment.** The account needs four things, whatever method produced them: an opening and a closing estimate of the **total** stock on a consistent basis, natural growth and natural mortality as separate entries, extraction measured as gross catch, and a documented statement of which of these were estimated independently and which were derived. Where the assessment supplies both endpoints directly, the accounting identity becomes a consistency check rather than a derivation, and any residual is entered as a reappraisal rather than absorbed silently.

¶6 Stock assessments commonly distinguish total stock, spawning stock biomass and exploitable stock[40]. The asset account takes the **total** stock; the other two are management reference points, and substituting one for another between periods breaks the time series without any change in the ocean. Where only a relative index such as catch per unit effort is available, the account cannot be closed on that index alone[41] and the limitation must be recorded in metadata; the index still carries a signal, since a declining CPUE trend "may be a signal that the rate of harvest is exceeding the renewal rate of the fish stock"[42], [43].

¶7 The choice of assessment method — virtual population analysis, surplus production, tag-recapture, acoustic or trawl survey — and the treatment of CPUE standardisation and technological creep are matters for **TG-6.7 Fisheries Accounting: Integrating Stock Assessment**, which also gives the tier mapping from assessment type to the account entries each can support.

¶8 **Classification of catch types**. The SEEA CF recommends using **gross catch** as the measure of extraction from natural aquatic resources[44]. Gross catch is defined as the total live weight of fish caught, comprising:

- ¶9 **Retained catch** — fish brought to shore as landings
- ¶10 **Discarded catch** — fish returned to the water, typically dead or dying

¶11 Using gross catch rather than landings matters because discards still remove fish from the ocean. In some fisheries, discards constitute a substantial fraction of total catch, so ignoring them would understate the impact on fish stocks. The SEEA CF notes that "the measurement of discarded catch is an important contributory factor to a full understanding of the linkages between economic activity and the impact on aquatic resources"[45]. Omitting discards would understate that impact.

¶12 Where direct measurement through at-sea observer programmes is unavailable, discard rates may be estimated using species-specific discard ratios from comparable fisheries, gear-type-specific discard rates from regional studies, or logbook-based self-reporting validated against observer data. For guidance on survey methods applicable to discard estimation, see **TG-4.2 Survey Methods for Ocean Economic Activity**.

¶13 **Physical asset account for aquatic resources**. Table 1 presents the structure of a physical asset account for aquatic resources, distinguishing between cultivated and natural resources.

Accounting entry	Cultivated aquatic resources	Natural aquatic resources	Total
Opening stock	12,000	180,000	192,000
Additions to stock			
– Growth in stock	3,500	28,000	31,500
– Upward reappraisals	–	5,000	5,000
– Reclassifications	200	–	200
Total additions	3,700	33,000	36,700
Reductions in stock			
– Gross catch/harvest	3,200	24,000	27,200
– Normal losses	400	15,000	15,400
– Catastrophic losses	–	2,000	2,000
– Uncompensated seizure	–	800	800
– Downward reappraisals	–	–	–
– Reclassifications	–	200	200
Total reductions	3,600	42,000	45,600
Closing stock	12,100	171,000	183,100

DRAFT

¶14 *Table 1: Structure of physical asset account for aquatic resources, with illustrative synthetic values in tonnes (adapted from SEEA CF Table 5.22)*[46]

¶15 The table includes "uncompensated seizure" to record illegal fishing by non-residents, following the SEEA CF treatment[47]. In this example the natural aquatic stock is declining (closing stock 171,000 < opening stock 180,000), driven by extraction and losses exceeding growth. Cultivated resources record modest growth, the pattern expected where aquaculture is expanding whilst wild fisheries are under pressure.

Combined physical asset account template

¶1 Table 1a provides a broader template that compilers can use to record all major categories of marine natural resources within a single accounting structure. It distinguishes natural aquatic resources (fish and other wild aquatic organisms), ecosystem assets (spatially defined marine ecosystem types measured by extent), and mineral and energy resources (seabed deposits). Each asset class follows different dynamics: fish grow and reproduce, ecosystems expand and contract, and minerals only deplete. The template captures these differences.

Entry	Natural Aquatic Resources	Ecosystem Assets	Mineral Resources
	(tonnes)	(hectares)	(tonnes)
Opening stock	180,000	72,000	5,200,000
Additions			
Natural growth	28,000	N/A	N/A
Natural expansion	N/A	120	N/A
Managed expansion	N/A	350	N/A
Discoveries	5,000	N/A	200,000

Entry	Natural Aquatic Resources	Ecosystem Assets	Mineral Resources
Upward reappraisals	5,000	80	100,000
Reclassifications in	–	50	–
Total additions	38,000	600	300,000
Reductions			
Extraction/Harvest	24,000	N/A	180,000
Natural reduction	15,000	400	N/A
Catastrophic losses	2,000	600	N/A
Managed reduction	N/A	200	N/A
Downward reappraisals	–	–	–
Reclassifications out	200	50	–
Total reductions	41,200	1,250	180,000
Closing stock	176,800	71,350	5,320,000
Derived entries			
Sustainable yield	22,000	N/A	N/A
Depletion	2,000	N/A	180,000

¶2 *Table 1a: Combined physical asset account template for marine natural resources with illustrative synthetic values (integrating SEEA CF Table 5.4, SEEA EA Table 4.1, and SEEA CF Table 5.22)* [48]

¶3 Note: Illustrative values are synthetic. In practice, discoveries of entirely new fish stocks are rare, and stock revisions are typically recorded as reappraisals rather than discoveries.

¶4 The "Derived entries" section highlights depletion as a key sustainability indicator. For renewable resources, depletion occurs only when extraction exceeds sustainable yield (24,000 - 22,000 = 2,000 tonnes in this example). For non-renewable resources, all extraction constitutes depletion — there is no regeneration to offset it. For natural aquatic resources, stock assessment models provide the primary input (see **TG-6.7 Fisheries Accounting: Integrating Stock Assessment**). For ecosystem assets, remote sensing and spatial survey provide extent mapping (see **TG-4.1 Remote Sensing and Geospatial Data**). For mineral resources, geological surveys and commercial assessments provide stock estimates.

¶5 **Sustainable yield and depletion**. For fisheries management, sustainable yield represents the maximum catch that can be taken without reducing the stock's long-term productivity. When gross catch exceeds sustainable yield, depletion occurs and should be recorded. Conversely, when catch is below sustainable yield, the excess regeneration contributes to stock growth rather than depletion [49]. The practical test: compare your catch to your sustainable yield estimate each year. If the gap is widening, management intervention is needed. The SEEA CF recommends that "estimates from biological models be compared with indicators of stock size, such as CPUE, and also that estimation be carried out on an ongoing basis so that the dynamics of the various populations (natural growth, natural losses, etc.) can be better understood" [50].

¶6 **Capture fishing by non-residents**. Under the SNA and SEEA CF, production is attributed to the country of residence of the harvesting operation, not the location of the resource [51]. For asset accounts, in contrast, the focus is on changes in the national aquatic resource. The SEEA CF states that "the total catch from the country's aquatic resources—including any resources on the high seas over which ownership rights exist, regardless of the residency of the harvesting operation" [52] must be recorded as reductions in the national stock. Foreign-flagged vessels fishing in your waters therefore reduce your asset account even though their production appears in another country's GDP.

¶7 **Illegal fishing**. The SEEA CF addresses illegal fishing explicitly: "If residents harvest aquatic resources beyond the scope of their licence, they are harvesting illegally. Nonetheless, following the principles of the SNA, this harvest should still be recorded as production with an income accruing to the fisherman" [53]. For illegal fishing by non-residents, the physical removals should be recorded as "uncompensated seizures" [54]. Excluding illegal catch from the asset account would overstate the closing stock, since the fish are removed regardless of whether they were caught legally.

¶8 **Monetary valuation of aquatic resources**. The SEEA CF describes two main options for valuing natural aquatic resources [55]:

1. ¶9 Using the value of long-term fishing licences and quotas where realistic market values are available
2. ¶10 Applying the NPV of expected resource rents

¶11 Where individual transferable quotas (ITQs) are used and traded, the total market value of all quotas may approximate the value of the aquatic resource [56]. Quota markets are, however, often imperfect, and quota values may not reflect the full value of the underlying resource. The SEEA CF notes that "because of market imperfections (barriers to entry in the form of specialized fixed assets, knowledge of fishing grounds, etc.), a lack of liquidity in the markets, and uncertainties in the statistical assumptions required for net present value calculations", different approaches "are unlikely to give the same result in practice" [57]. Compilers should therefore document which method they used and why, rather than assuming that any single approach yields the "right" answer.

3.4.2 Mineral and energy resources

¶1 Mineral and energy resources in the ocean domain include offshore oil and gas deposits, seabed minerals (including polymetallic nodules, cobalt-rich ferromanganese crusts, and seafloor massive sulphides), sand and gravel, and other extractable minerals [58]. Unlike fish stocks, these resources do not regenerate on human timescales — every unit extracted is permanent depletion.

¶2 **Classification of resources**. The SEEA CF classifies mineral resources based on commercial viability, which determines how they enter the accounts [59]. Table 3.4.2 below summarises the three classes.

Class	Description
Class A — Commercially recoverable	Economically viable to extract under current conditions.
Class B — Potentially commercially recoverable	May become viable with technological advances or price changes.
Class C — Non-commercial and other known deposits	Not currently viable.

¶3 This classification matters because movements between classes (a deposit becoming commercially viable as technology improves) are recorded as reclassifications, not discoveries. Understanding this distinction prevents double-counting.

¶4 **Physical asset accounts for minerals**. Asset accounts for mineral and energy resources record the opening stock, discoveries, extractions, reappraisals, and closing stock[60]. Because these are non-renewable resources with no natural growth, depletion equals extraction. Measurement units vary by resource type (barrels for oil, cubic metres for gas, tonnes for minerals).

¶5 For deep-sea minerals in areas beyond national jurisdiction (ABNJ), the regulatory framework under the International Seabed Authority (ISA) continues to develop. The BBNJ Agreement, which entered into force on 17 January 2026, establishes new governance arrangements for biodiversity in ABNJ that may have implications for asset accounting boundaries. Compilers should note that mineral resources in ABNJ are designated as the "common heritage of mankind" under UNCLOS and are administered by the ISA. Asset accounts for ABNJ minerals should reflect the access and benefit-sharing provisions of the applicable regulatory framework. For further guidance on deep-sea and ABNJ accounting, see **TG-6.6 Deep-Sea and ABNJ**.

¶6 **Monetary valuation**. The NPV approach is typically applied, using the expected resource rent — the surplus after all extraction costs and normal returns to produced assets have been deducted[61]. Resource rent can be estimated as a residual from operating surplus or from royalty payments where these approximate market rent. For detailed guidance on resource rent estimation, see **TG-1.9 Safe Usage of Monetary Valuation**.

3.4.3 Water resources

¶1 The SEEA CF defines water resources as "freshwater and brackish water in inland water bodies, including groundwater and soil water"[62]. Seawater is excluded from the asset boundary because "the stocks are too large to be meaningful for analytical purposes"[63]. The open ocean is therefore not tracked as an asset, whilst the interfaces between freshwater and marine systems remain important.

¶2 For coastal areas, groundwater in coastal aquifers may be subject to saltwater intrusion, and estuarine systems represent transitional zones where freshwater and marine systems interact. Asset accounts for water resources should capture these coastal dynamics where relevant. The SEEA CF notes that "water is in continuous movement through the processes of precipitation, evaporation, run-off, infiltration and flows to the sea"[64], and this hydrological connectivity must be considered in coastal accounting. A coastal aquifer losing freshwater to saltwater intrusion is an asset account reduction that directly affects the communities and agriculture that depend on that aquifer.

3.5 Ecosystem Assets

¶1 SEEA Ecosystem Accounting extends asset accounting to treat ecosystems as integrated spatial units: the whole living system, of which the fish or minerals within it are components[65]. An **ecosystem asset** is defined as "contiguous spaces covered by a specific ecosystem type characterized by a distinct set of biotic and abiotic components and their interactions"[66]. For ocean accounting, ecosystem assets include coral reefs, mangrove forests, seagrass meadows, kelp forests, coastal wetlands, and the various pelagic and deep-sea ecosystem types.

¶2 This ecosystem-level view captures something that individual asset accounts omit: the interdependence of marine systems. A coral reef supplies coastal protection, supports tourism, sequesters carbon, and maintains biodiversity, alongside its fish. Tracking the reef as a whole records whether these combined services are being sustained or degraded. The relationship between ecosystem assets and the individual environmental assets described in Section 3.4 is addressed in **TG-0.2 Overview of Relevant Statistical Standards**.

3.5.1 Ecosystem extent accounts

¶1 **Ecosystem extent** is the size of an ecosystem asset, measured in units of area (or, for some marine ecosystems, length or volume)[67]. Extent accounts answer a basic question: how much of each ecosystem type do you have, and is it growing or shrinking? The extent account uses the same opening-plus-additions-minus-reductions identity as the Central Framework natural-resource account (Figure 3.1.1), but adds an attribution of every addition and reduction by cause — managed change from direct human activity versus unmanaged change from natural processes (Figure 3.1.2).

DRAFT

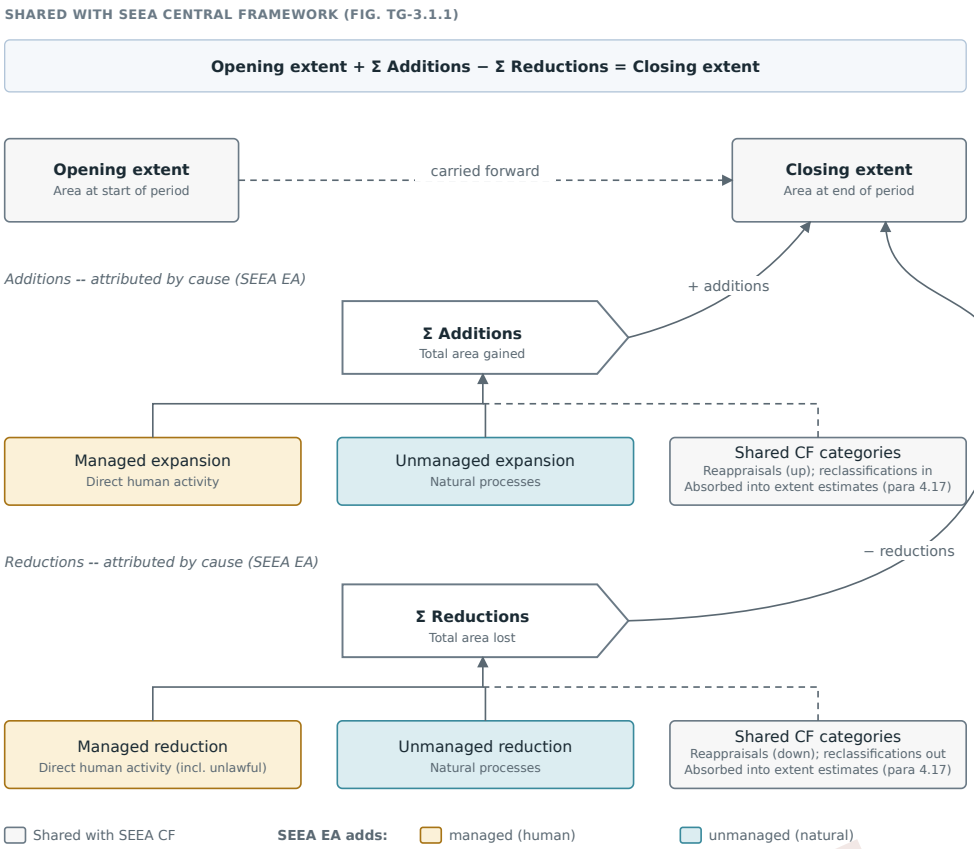


Figure 3.1.2 SEEA Ecosystem Accounting keeps the Central Framework stock-flow identity and adds managed versus unmanaged cause attribution for each change. Colour marks the cause split on shared CF structure; illustrated for extent (area conversions). Same attribution applies in carbon and monetary ecosystem asset accounts.

Source: SEEA EA 2024 para 13.63 (shared CF asset-account form); paras 4.14-4.27 and Table 4.1 (extent account, managed/unmanaged); paras 10.2.2-10.2.3 (enhancement/degradation); TG-3.1.

Adapted from: SEEA EA 2024 Table 4.1, recast to highlight the concepts SEEA EA adds to the shared Central Framework asset-account identity for TG-3.1.

¶2 **Structure of extent accounts**. The structure follows the standard asset account format [68]:

Accounting entry	Ecosystem Type A	Ecosystem Type B	...	Total
Opening extent	15,000	8,500	...	72,000
Additions to extent				
– Managed expansion	250	100	...	350
– Natural expansion	80	40	...	120
Total additions	330	140	...	470
Reductions in extent				
– Managed reduction	150	50	...	200
– Natural reduction	300	100	...	400
Total reductions	450	150	...	600
Net change in extent	-120	-10	...	-130
Closing extent	14,880	8,490	...	71,870

¶3 *Table 2: Structure of ecosystem extent account with illustrative synthetic values in hectares (adapted from SEEA EA Table 4.1)* [69]

¶4 **Structural template – opening/closing extent account (SEEA EA Table 4.1).** Table 2a presents the same account as a blank structural template, ready to be populated. The row structure follows the standard SEEA asset-account logic (opening stock, additions, reductions, closing stock), whilst the columns are the ecosystem types selected for the accounting area [70]. Compilers should populate one column per ecosystem type in the EAA, using a consistent unit of area (e.g., hectares or square kilometres) throughout. The accounting identity is: *Opening extent + Total additions − Total reductions = Closing extent*, and the sum of closing extents across all ecosystem types should equal the total area of the EAA [71].

¶5 **Table 2a: Opening/closing extent account – structural template (after SEEA EA Table 4.1)**

Accounting entry	Ecosystem type 1	Ecosystem type 2	…	Ecosystem type *n*	Total
Opening extent (start of period)	[area]	[area]	…	[area]	[Σ area]
Additions to extent					
– Managed expansion	[area]	[area]	…	[area]	[Σ area]
– Unmanaged expansion	[area]	[area]	…	[area]	[Σ area]
Total additions	[Σ]	[Σ]	…	[Σ]	[ΣΣ]
Reductions in extent					
– Managed reduction	[area]	[area]	…	[area]	[Σ area]
– Unmanaged reduction	[area]	[area]	…	[area]	[Σ area]
Total reductions	[Σ]	[Σ]	…	[Σ]	[ΣΣ]
Net change in extent	[+/-]	[+/-]	…	[+/-]	[+/-]
Closing extent (end of period)	[area]	[area]	…	[area]	[Σ area = total EAA]

¶6 *Table 2a: Structural template of an ecosystem extent account; cells are left blank to be populated by the compiler with no synthetic values. Row labels follow SEEA EA paras 4.10 and 4.15; column structure follows SEEA EA paras 4.11–4.13.* [70], [71]

¶7 The accounting entries are defined by the SEEA EA as follows (para 4.15) [71]:

- ¶8 **Opening extent** and **closing extent** – the total area of ecosystem assets for a given ecosystem type at the beginning and end of the accounting period (generally one year).
- ¶9 **Additions to extent** – increases in the area of an ecosystem type, separated where possible into:
  - ¶10 **Managed expansions** – increases due to direct human activity (e.g., land reclamation, reforestation), including the unplanned effects of such activity.
  - ¶11 **Unmanaged expansions** – increases resulting from natural processes (e.g., seeding, sprouting, succession), which may be influenced by human activity (e.g., climate-driven shifts) or result from land abandonment.
- ¶12 **Reductions in extent** – decreases in the area of an ecosystem type, separated where possible into:
  - ¶13 **Managed reductions** – decreases due to direct human activity (e.g., deforestation, urban expansion), including unplanned or illegal activity.
  - ¶14 **Unmanaged reductions** – decreases associated with natural processes (e.g., loss of coral reefs to climate change, abandonment).

¶15 Where data availability does not permit the managed/unmanaged split, SEEA EA para 4.14 advises that it is sufficient to record opening and closing extents and the net change [72]. Revisions arising from updated input data or methods are not recorded as a distinct entry. Instead, opening/closing extents and additions/reductions are altered and time series revised (para 4.17) [72].

¶16 **Ecosystem conversions**. Changes in ecosystem extent are termed **ecosystem conversions** – situations where "for a given location, there is a change in ecosystem type involving a distinct and persistent change in ecological structure, composition and function" [73]. Conversions may be human-induced (such as clearing mangroves for aquaculture ponds) or natural (such as succession of wetland types). Within the extent account, the total area of all ecosystem types should equal the total ecosystem accounting area: what one type loses, another type gains.

¶17 **Conversions are recorded in the extent account, not beside it.** A conversion changes the ecosystem type of an area that remains inside the accounting area, so it is not a reduction in the same sense as an area lost from the accounting area altogether. Where conversions are material, add a reclassification block to Table 2a between additions and reductions:

Accounting entry	Ecosystem type 1	Ecosystem type 2	…	Total
Reclassifications				
– Conversions from other ecosystem types	[area]	[area]	…	[Σ area]
– Conversions to other ecosystem types	[-area]	[-area]	…	[-Σ area]
Net reclassification	[+/-]	[+/-]	…	**0**

¶18 *Table 2b: Reclassification block for the ecosystem extent account. Net reclassification sums to zero at the total level: an area converted out of one ecosystem type is an area converted into another.*

¶19 The distinction that governs which row an event enters is whether the area changes **type** or leaves the **accounting area**. Kelp lost to storm damage where the substrate is exposed but not yet colonised is an unmanaged reduction; kelp that becomes an urchin barren is a reclassification, because the area is still accounted for, under a different type. Compilers who cannot yet support a reclassification block should record conversions in a separate ecosystem type change matrix and state in account metadata that they have done so, but the block above is the preferred presentation because it keeps the conversion inside the account that has to balance.

¶20 **Marine ecosystem delineation**. For marine ecosystems, the SEEA EA recommends that within the continental shelf, "ecosystem assets be delineated based on the areas of the different ecosystem types associated with the seabed, for example, seagrass meadows, subtidal sandy bottoms and coral reefs" [74]. This seabed-based approach accommodates the three-dimensional nature of marine ecosystems whilst providing a practical basis for area measurement. The SEEA EA also notes that "marine ecosystems are not concentrated near one surface (i.e. the air-land/water interface) but extend throughout the water column and include the underlying sediment and seabed" [75]. Mapping therefore proceeds from the seabed upward: the seabed type defines the ecosystem boundary, even though the living system extends through the water column above it.

¶21 The IUCN Global Ecosystem Typology (GET) provides the reference classification for marine ecosystem types, with the Marine Shelf biome (M1) encompassing key functional groups including seagrass meadows (M1.1), kelp forests (M1.2), photic coral reefs

DRAFT

(M1.3), shellfish beds and reefs (M1.4), and subtidal rocky reefs (M1.6)[76]. For guidance on mapping marine ecosystem extent using remote sensing and spatial data, see **TG-4.1 Remote Sensing and Geospatial Data**.

¶22 The seabed-based delineation approach presents challenges for pelagic ecosystems that are not clearly associated with specific seabed areas. Epipelagic, mesopelagic, and bathypelagic ecosystem types (IUCN GET M2.1–M2.4) require alternative delineation approaches, potentially using water mass characteristics, depth zones, or biogeochemical provinces as boundaries. These challenges are addressed in **TG-6.5 Pelagic and Open Ocean Accounts**.

3.5.2 Ecosystem condition accounts

¶1 **Ecosystem condition** refers to the quality of an ecosystem — how well it is functioning, as distinct from how much of it exists[77]. A hectare of degraded coral reef is still a hectare in the extent account, but its capacity to deliver services (coastal protection, fish habitat, tourism value) may be a fraction of a healthy reef's. Condition accounts capture this quality dimension.

¶2 **Structure of condition accounts**. The SEEA EA describes a three-stage measurement approach[78], summarised in Table 3.5.2 below.

Stage	Description
Condition variable accounts	Record raw values of condition characteristics (e.g., live coral cover percentage, species richness count, water temperature).
Condition indicator accounts	Transform variables into comparable indicators, typically scaled against a reference condition (e.g., coral cover as a percentage of reference condition).
Condition indices	Aggregate indicators into composite measures for communication to policy-makers (optional).

¶3 **Selection of condition variables**. Condition variables should be selected based on their relevance to the ecosystem type, data availability, and connection to ecosystem integrity[79]. For marine ecosystems, the SEEA EA identifies key drivers of condition including bathymetric profile, climate factors (temperature, acidification), substrate type, ocean circulation, salinity, and human pressures[80]. The SEEA EA groups condition characteristics into six classes[81]:

- ¶4 Physical state (including water temperature, salinity)
- ¶5 Chemical state (including ocean acidification, nutrient levels, pollutant concentrations)
- ¶6 Compositional state (including species diversity, community composition)
- ¶7 Structural state (including habitat complexity, biomass)
- ¶8 Functional state (including productivity, ecosystem processes)
- ¶9 Landscape/seascape context (including connectivity, fragmentation)

¶10 For guidance on indicators derived from ecosystem condition accounts, see **TG-2.1 Aggregate Biophysical Indicators of Environmental State**.

Relationship between extent, condition, and service capacity

¶1 The capacity of an ecosystem to deliver services depends on both its extent and its condition — area multiplied by quality. A large, healthy reef delivers more services than a small, degraded one. SEEA EA Figure 6.1 illustrates this relationship: ecosystem extent determines the spatial scale of potential service delivery, whilst ecosystem condition determines the quality and intensity of service flow per unit area[82]. Together, they determine the overall capacity to deliver ecosystem services, which is then realised through actual service flows to economic units.

¶2 Figure 3.1.3 shows the relationship between ecosystem extent, condition, and service capacity (adapted from SEEA EA Figure 6.1).

DRAFT

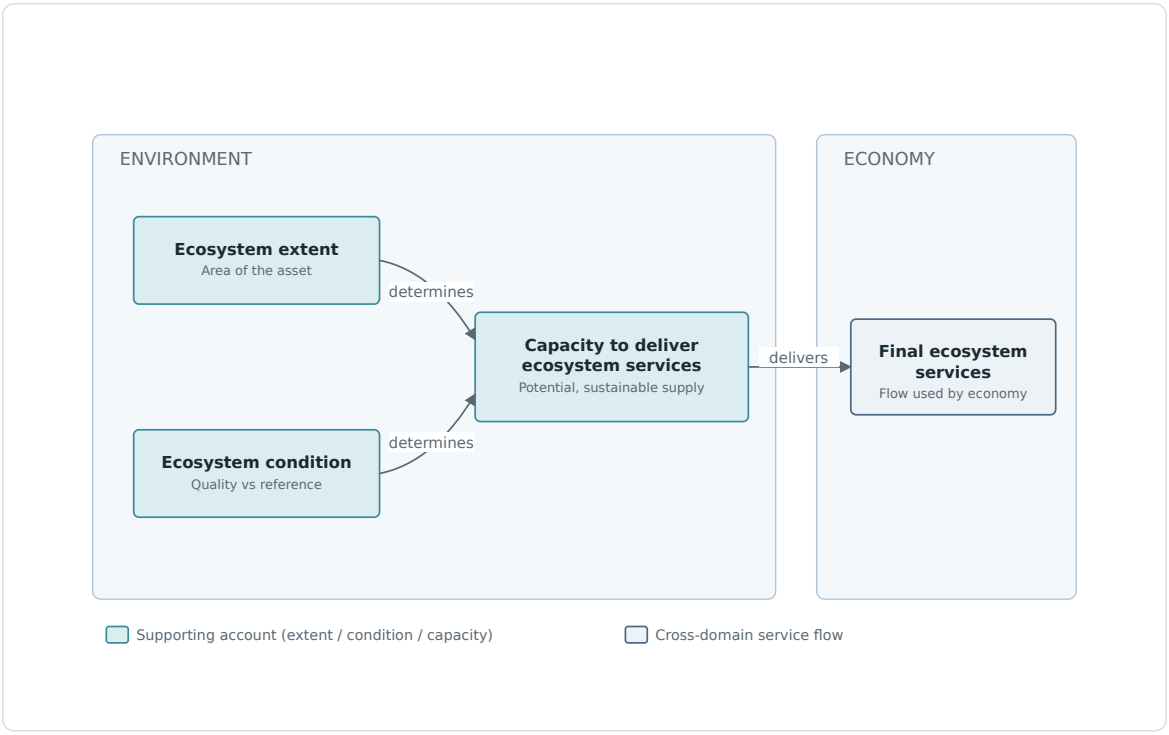


Figure 3.1.3 Ecosystem extent and condition jointly determine capacity -- the potential sustainable supply realised as final service flows to the economy. Extent, condition, and capacity are supporting accounts; the final service flow crosses the Environment--Economy boundary.

¶3 This framework has direct implications for ocean accounting. A decline in coral reef extent (recorded in the extent account) reduces the total area available for service delivery. Simultaneously, degradation in reef condition (recorded in the condition account) reduces the service flow per hectare. Both effects are captured when compiling ecosystem service flow accounts as described in **TG-3.2 Flows from Environment to Economy**.

Illustrative marine condition variables by ECT class

¶1 To support the selection of condition variables for marine ecosystem types, Table 3 maps illustrative variables to the six classes of the SEEA EA Ecosystem Condition Typology (ECT)[83]. The ECT provides a universal structure for organising condition characteristics across all ecosystem types, and groups them into abiotic, biotic, and landscape-level categories.

DRAFT

ECT Group	ECT Class	Marine condition variables (illustrative)
Group A: Abiotic	A1. Physical state	Sea surface temperature (°C), salinity (PSU), turbidity (NTU), microplastic concentration (particles/m³)
	A2. Chemical state	Ocean pH, dissolved oxygen (mg/L), chlorophyll-a (µg/L), nutrient concentrations (N, P)
Group B: Biotic	B1. Compositional state	Species richness (number), abundance of key species (individuals/area), invasive species presence
	B2. Structural state	Live coral cover (%), seagrass canopy height (cm), mangrove canopy density (%), fish biomass (kg/ha)
	B3. Functional state	Net primary productivity (gC/m²/yr), trophic index, recruitment rates
Group C: Landscape	C1. Landscape/seascape	Habitat connectivity index, fragmentation (patch count), distance to pressure sources (km)

¶2 *Table 3: Illustrative marine condition variables structured by ECT class (based on SEEA EA Table 5.1)*[83]

¶3 The SEEA EA recommends selecting at least one variable for each of the six ECT classes for each ecosystem type, which sets a minimum level of coverage[84]. Each variable should be compared against a reference condition representing "good" or "natural" state, so that it can be transformed into condition indicators that are comparable across ecosystem types and accounting periods. Based on evaluation of existing ecosystem condition accounts, a set of approximately 6 to 10 well-selected indicators for a given ecosystem type should provide sufficient information to assess the overall condition of an ecosystem asset[85]. For biome-specific indicative variables, including those relevant to marine shelf, pelagic, and deep-sea biomes, compilers should consult the indicative variable sets presented in SEEA EA Table 5.7[86].

¶4 **Reference conditions**. Condition indicators are typically expressed relative to a reference level representing "good" or "natural" condition[87]. The reference condition may be a historical baseline, a minimally impacted area, or a policy target, and the choice should be clearly documented. A reef measured against a pristine 1950s baseline may record a 60% decline, whilst the same reef measured against a 2010 baseline may appear stable. The choice of reference therefore shapes how the account is interpreted. The SEEA EA links condition to the concept of **ecosystem integrity**: "the ecosystem's capacity to maintain its characteristic composition, structure, functioning and self-organization over time within a natural range of variability"[88].

The three condition account tables

¶1 The three stages produce three account tables. Compilers should publish all three: the variable account is the auditable record, the indicator account is what can be compared across ecosystem types, and the index is what reaches a policy reader. Publishing only the index hides the choices that produced it.

¶2 **Stage 1 — condition variable account.** Records each selected variable in its own measured units, unrescaled, for the opening and closing of the accounting period, together with the upper and lower reference levels against which it will be rescaled. The reference levels are fixed at the start of the time series and held constant (**TG-4.8** Section 3.1).

¶3 **Table 3a: Ecosystem condition variable account — structural template (after SEEA EA Table 5.2)**

ECT class	Condition variable	Unit	Polarity	Lower reference *L*	Upper reference *U*	Opening value	Closing value
A1 Physical state	[variable]	[unit]	Normal / Inverse	[L]	[U]	[value]	[value]
A2 Chemical state	[variable]	[unit]	Normal / Inverse	[L]	[U]	[value]	[value]
B1 Compositional state	[variable]	[unit]	Normal / Inverse	[L]	[U]	[value]	[value]
B2 Structural state	[variable]	[unit]	Normal / Inverse	[L]	[U]	[value]	[value]
B3 Functional state	[variable]	[unit]	Normal / Inverse	[L]	[U]	[value]	[value]
C1 Landscape/seascape	[variable]	[unit]	Normal / Inverse	[L]	[U]	[value]	[value]

¶4 *Table 3a: Structural template of an ecosystem condition variable account, one table per ecosystem type in the accounting area. Cells are blank for compiler population. Row structure follows the ECT classes in Table 3; the reference-level and polarity columns carry the parameters the Stage 2 rescaling consumes.*

¶5 **Stage 2 — condition indicator account.** Rescales each variable to a dimensionless 0–1 indicator against its reference levels. **The transformation is not defined here.** It is normative in **TG-2.1 Aggregate Biophysical Indicators of Environmental State** Section 3.4.1 — `Indicator = (V - L) / (U - L)` for normal polarity, `(L - V) / (L - U)` for inverse polarity, with the categorical step deduction for pH and other logarithmic-scale variables — and compilers must use that transformation without local variation.

¶6 **Table 3b: Ecosystem condition indicator account — structural template (after SEEA EA Table 5.3)**

ECT class	Condition indicator	Opening indicator (0–1)	Closing indicator (0–1)	Change	Data tier
A1 Physical state	[indicator]	[0–1]	[0–1]	[+/-]	1 / 2 / 3
A2 Chemical state	[indicator]	[0–1]	[0–1]	[+/-]	1 / 2 / 3
B1 Compositional state	[indicator]	[0–1]	[0–1]	[+/-]	1 / 2 / 3
B2 Structural state	[indicator]	[0–1]	[0–1]	[+/-]	1 / 2 / 3
B3 Functional state	[indicator]	[0–1]	[0–1]	[+/-]	1 / 2 / 3
C1 Landscape/seascape	[indicator]	[0–1]	[0–1]	[+/-]	1 / 2 / 3

DRAFT

¶7 *Table 3b: Structural template of an ecosystem condition indicator account. Every value is dimensionless and bounded on [0, 1], which is what makes rows comparable across ecosystem types and periods. The data tier column carries the quality flag defined in TG-4.8 Section 3.2 and TG-4.9 Section 3.4.*

¶8 **Stage 3 — condition index.** Aggregates the indicators, first to a class-level sub-index and then to a single index for the ecosystem type. SEEA EA describes three aggregation rules in common use: the (weighted) arithmetic mean, the (weighted) geometric mean, and one-out-all-out, in which the index takes the value of its worst-performing indicator. The choice matters and is not neutral: an arithmetic mean lets a strong indicator mask a collapsed one, a geometric mean penalises imbalance, and one-out-all-out is the precautionary rule used in several regulatory regimes. **TG-2.1** Section 3.6 sets the publication default and is normative; the weights and the rule applied must be recorded in the account.

¶9 **Table 3c: Ecosystem condition index — structural template (after SEEA EA Table 5.4)**

Level	Component	Weight	Opening	Closing	Change
Class sub-index	A1 Physical state	[w]	[0–1]	[0–1]	[+/-]
Class sub-index	A2 Chemical state	[w]	[0–1]	[0–1]	[+/-]
Class sub-index	B1 Compositional state	[w]	[0–1]	[0–1]	[+/-]
Class sub-index	B2 Structural state	[w]	[0–1]	[0–1]	[+/-]
Class sub-index	B3 Functional state	[w]	[0–1]	[0–1]	[+/-]
Class sub-index	C1 Landscape/seascape	[w]	[0–1]	[0–1]	[+/-]
Ecosystem condition index	**All classes**	—	**[0–1]**	**[0–1]**	**[+/-]**

¶10 *Table 3c: Structural template of an ecosystem condition index. Record the aggregation rule and the weights alongside the table; an index published without them cannot be reproduced or challenged.*

¶11 The closing index in Table 3c is the value the degradation calculation in Section 3.5.3 consumes, and the change column is the index-point decline that formula takes as its input. A compiler who has not produced Table 3c cannot produce a defensible degradation entry.

3.5.3 Monetary ecosystem asset accounts

¶1 Monetary ecosystem asset accounts record the value of ecosystem assets in currency units. The SEEA EA presents two main valuation approaches [89]:

1. ¶2 **NPV of ecosystem services** – summing the discounted future flows of all ecosystem services supplied by the asset
2. ¶3 **Restoration cost** – the cost of restoring an ecosystem to a reference condition

¶4 The NPV approach aligns with valuation methods for other natural assets but requires monetary valuation of ecosystem services, which remains methodologically challenging, particularly for non-market services such as coastal protection and biodiversity maintenance. The restoration cost approach provides an alternative that does not require service valuation but may not reflect the full economic value of the asset. A coral reef may cost a certain amount to restore, whilst its actual value to the economy and society may be far higher. For detailed guidance on valuation of ecosystem services, see **TG-1.9 Safe Usage of Monetary Valuation** and **TG-2.4 Ecosystem Goods and Services**.

Structure of monetary ecosystem asset accounts

¶1 The SEEA EA monetary ecosystem asset account (Chapter 10) records the monetary values of all ecosystem assets within an ecosystem accounting area at the beginning and end of each accounting period, together with the changes in those values [90]. Table 4 presents the standard structure.

Accounting entry	Ecosystem Type A	Ecosystem Type B	...	Total
Opening value	84,000	42,500	...	360,000
Ecosystem enhancement	1,200	300	...	1,500
Ecosystem degradation	-2,500	-800	...	-3,300
Ecosystem conversions (additions)	400	200	...	600
Ecosystem conversions (reductions)	-600	-250	...	-850
Other changes in volume				
– Catastrophic losses	-1,500	-400	...	-1,900
– Reappraisals	800	100	...	900
Revaluation	1,100	400	...	1,500
Net change in value	-1,100	-450	...	-1,550
Closing value	82,900	42,050	...	358,450

¶2 *Table 4: Structure of monetary ecosystem asset account with illustrative synthetic values in thousand currency units (adapted from SEEA EA Table 10.1)* [90]

¶3 The account balances on the identity *Closing value = Opening value + enhancement – degradation + conversions (additions) – conversions (reductions) + other changes in volume + revaluation*, and the net change row makes that visible. In this illustration degradation and catastrophic losses together exceed enhancement, reappraisals and holding gains, so the closing value is below the opening value: the accounting area ended the period with less ecosystem wealth than it started with. That is the signal the account exists to carry, and it is the one a compiler should check first.

¶4 The accounting entries distinguish five broad types of change in the monetary value of ecosystem assets [91]:

- ¶5 **Ecosystem enhancement** records increases in monetary value associated with improving condition during the accounting period. This includes the effects of active restoration, reductions in harmful activities that allow recovery, and natural improvements in condition. A positive enhancement entry indicates that investment in ecosystem health is generating economic returns.
- ¶6 **Ecosystem degradation** records decreases in monetary value associated with declining condition. Degradation plays an analogous role to depletion for individual natural resources: it represents a cost that should be deducted in calculating adjusted income measures. Consistently large degradation entries indicate an economy drawing down its ecosystem capital.
- ¶7 **Ecosystem conversions** record additions and reductions resulting from changes in ecosystem type at a given location. When mangroves are cleared for aquaculture, a decrease in value is recorded for mangroves and an increase for the new aquaculture pond ecosystem. There is no expectation that these will be offsetting in monetary terms, as mangroves typically provide far more total ecosystem services than the aquaculture ponds that replace them.
- ¶8 **Other changes in volume** capture two categories: **catastrophic losses**, which are decreases in value due to large-scale, discrete events that cause significant loss in ecosystem condition – significant losses in structure, function or composition – such as a mass bleaching event, a cyclone or an oil spill (SEEA EA paras 10.24, 10.37); and **reappraisals**, which record changes in value due to updated information about expected future demand for ecosystem services or changed expectations about future condition (SEEA EA para 10.38) [92]. Where such an event is severe enough that the ecosystem is considered to have changed its type, the loss is recorded as an **ecosystem conversion**, not as a catastrophic loss (SEEA EA para 10.37). The line therefore turns on whether condition fell or type changed, not on how much extent was affected.
- ¶9 **Revaluation** records changes in monetary value due solely to movements in the unit prices of ecosystem services, distinct from any physical changes in the asset. Following the SEEA CF convention, changes in value resulting from changes in the quantity or quality of future flows of ecosystem services are not revaluations and should be recorded under the appropriate entry above (SEEA EA para 10.41) [93].

¶10 The distinction between reappraisals and revaluation is essential for interpreting changes in ecosystem asset values. Reappraisals concern changes in expectations – for example, revised demographic projections that alter the expected future demand for ecosystem services, or rezoning decisions that change the expected pattern of ecosystem use. Revaluations, by contrast, concern changes in unit prices only and are conceptually equivalent to the holding gains and losses recorded for other asset types in the SNA.

DRAFT

¶11 For marine contexts, monetary values of ecosystem assets can be estimated using the NPV of expected future ecosystem service flows. For market services such as fish provisioning and blue carbon sequestration, resource rent methods may be applied. For non-market services such as coastal protection, water purification, and recreational amenity, replacement cost or avoided damage cost methods from the preference hierarchy in **TG-2.4 Environmental (including Ecosystem) Goods and Services** Section 3.10.2 should be used.

¶12 The UN Statistical Commission, in adopting the SEEA EA in 2021, identified "outstanding methodological concerns related to chapters 8 to 11 on valuation" (SEEA EA Preface para 8). Accordingly, the valuation chapters have the status of "internationally recognised statistical principles and recommendations" rather than a full international statistical standard. Compilers should be aware that monetary ecosystem asset valuation methods continue to evolve, and should document the methods and assumptions used in their valuations transparently.

Horizon and condition-to-service scaling

¶13 Two choices govern any NPV-based ecosystem asset valuation and should be recorded in account metadata.

¶14 **Apply the condition adjustment once.** A condition-adjusted asset value is built by adjusting the *physical service flow* for observed condition — treating a literature-derived or reference-condition service rate as the reference value and scaling it by the composite condition index — and then discounting the resulting condition-adjusted flow. The condition index enters at the service-flow step and **not again** at the discounting step. Applying it at both steps squares the adjustment and understates the asset, and it is a common error because each step looks defensible in isolation. Where condition is on a declining trajectory, project the service flow forward using the trend rather than applying a perpetuity to a single adjusted flow, and record the projected trajectory, its source and the horizon in account metadata.

¶15 **Perpetuity or finite horizon.** A perpetuity is appropriate where there is no foreseeable terminal date for the ecosystem asset, governance arrangements are stable, and any management mandate over the area is continuously renewed. A finite-horizon NPV is required where the arrangement that sustains the service flow has a time-limited mandate, a sunset clause, or uncertain renewal — a protected area designated for a fixed term, or a concession-dependent management regime. The choice materially changes the asset value, and the rationale must be documented.

¶16 **Condition-to-service scaling.** Where a change in the composite condition index is used to infer a change in service flow, **compilers should not assume a linear relationship as a default**. The relationship between condition and service capacity is service-specific: coastal protection, carbon sequestration and fishery support functions each have distinct functional forms, and several are known to be non-linear near ecological thresholds. Compilers should apply the best available ecological or economic evidence for the service in question, and document the functional form and its source. A linear scaling may be used as a screening-level approximation where no calibrated relationship is available, provided it is labelled as such and the direction of likely bias is stated. **TG-1.6 OA and Environmental Impact Assessment** Section 3.5 sets out how an assessor applies these conditions in practice, and why a damage cost must be reported as a range.

Ecosystem degradation, damage cost and offsets

¶17 Degradation is the decline in the monetary value of an ecosystem asset arising from a decline in its condition during the accounting period. This subsection specifies how it is calculated, when the simplified approach is defensible, and how the same extent-and-condition arithmetic supports offset requirements under no-net-loss policies.

Applicability of the simplified linear approximation

¶18 Before applying the degradation formula below, practitioners should confirm that the linear approximation is appropriate for their context. The simplified linear formula is appropriate only where all three of the following conditions are met:

¶19 **(a) Condition decline is 20 percentage points or less**, that is, the absolute change in the condition index does not exceed 0.20. This cut-off is indicative compiler judgement rather than a SEEA-specified threshold, and practitioners should adjust it where domain-specific evidence supports a different value. Larger declines are more likely to involve non-linear service losses.

¶20 **(b) No threshold responses are documented** in the relevant ecosystem literature for the ecosystem type and service combination being valued. If published studies indicate that condition decline triggers disproportionate service loss at any intermediate point within the predicted range, the linear approximation will underestimate damage.

¶21 **(c) A single dominant service type drives asset value** (i.e., one service accounts for more than approximately 70% of total annual service flow value per hectare, an indicative threshold that is not SEEA-specified). Where multiple services of roughly equal weight respond differently to the same condition change, separate service-specific calculations should replace the aggregated formula.

¶22 **Decision checklist:**

- ¶23 ☐ Is absolute condition decline 0.20 or less? If no, use an ecosystem-specific biophysical model (see the Guidelines on Biophysical Modelling cited below).
- ¶24 ☐ Does the ecosystem literature document threshold responses within the predicted condition range? If yes, use biophysical model or apply conservative non-linear adjustment (e.g., service loss proportional to condition decline squared). Consult the Guidelines on Biophysical Modelling for Ecosystem Accounting [94].
- ¶25 ☐ Does one service type account for more than approximately 70% of asset value? If no, calculate degradation separately for each major service.

Degradation formula

¶26 Degradation (simplified linear approximation) = (Condition decline) × (Present value of affected service flows)

¶27 **Definition of "condition decline":** In this formula, "condition decline" means the absolute change in the condition index, expressed in index points. For example, if the condition index falls from 0.72 to 0.60, the condition decline is 0.12 (not the proportional change of 16.7% relative to opening condition). Practitioners must use the absolute index-point change consistently throughout all calculations.

DRAFT

¶28 The formula is applied to project-level impact assessment in **TG-1.6 OA and Environmental Impact Assessment** Section 3.5. Consider a coastal development expected to reduce coral reef condition index from 0.75 to 0.60 (a decline of 0.15 index points) across 100 hectares. If the reef provides coastal protection services valued at USD 10,000/ha/year and biodiversity habitat services valued at USD 2,000/ha/year, and using a 4% discount rate for perpetual service flows (consistent with social discount rates used in several OECD national accounting frameworks, and practitioners should substitute their national treasury or green book rate):

¶29 **Worked calculation:**

- ¶30 Annual service flow per hectare = USD 12,000/ha/year
- ¶31 Asset value per hectare (perpetual annuity) = USD 12,000 / 0.04 = USD 300,000/ha
- ¶32 Total reef asset value (100 ha) = USD 30,000,000
- ¶33 Degradation (0.15 index-point condition decline) = 0.15 × USD 30,000,000 = **USD 4,500,000**

¶34 **Discount rate sensitivity:** As the choice of discount rate affects damage cost estimates, practitioners should present results across a range of rates. For the worked example above (USD 30,000,000 total asset value at 4%, condition decline = 0.15):

Discount rate	Asset value (100 ha)	Degradation cost (0.15 decline)
2%	USD 60,000,000	USD 9,000,000
4%	USD 30,000,000	USD 4,500,000
7%	USD 17,143,000	USD 2,571,000

¶35 If engineering solutions to reduce reef impacts would cost USD 4,000,000, the cost-benefit comparison at the 4% rate suggests such measures are economically justified. Discount rate selection is covered in Section 3.3 of this Circular and in **TG-2.4** Section 3.10; **TG-1.9 Safe Usage of Monetary Valuation** sets out how the resulting figures should be presented and caveated.

¶36 **Important methodological considerations:**

¶37 **Service-specific responses**: Different ecosystem services may respond differently to the same condition change. For example, coral cover decline may reduce coastal protection services linearly but reduce biodiversity habitat services exponentially if critical shelter structures are lost. Degradation estimates should separately assess each major service type.

¶38 **Uncertainty**: Both condition predictions and service valuations involve uncertainty. Practitioners should propagate uncertainty through calculations and present results as ranges rather than point estimates where feasible.

Offset requirement and restoration equivalence

¶39 Extent and condition accounts provide the quantitative foundation for environmental offset and no-net-loss policies, which apply in a growing number of marine regulatory contexts. The regulatory and procedural side of offsetting is covered in **TG-1.6 OA and Environmental Impact Assessment** Section 3.7; the measurement definitions are set out here so that they are available to compilers and regulators approaching from the accounts. Ecosystem extent and condition accounts establish the quantitative baselines against which offset requirements can be calculated. The offset requirement formula uses the condition index of the habitat that is lost (or degraded), not the condition gain from a restoration action. Consider a port expansion that will result in the loss of 5 hectares of seagrass at condition index 0.80. The offset requirement is:

DRAFT

> *Offset requirement = (Lost extent) × (Condition of lost habitat) × (Multiplier)*

¶40 **Note on the multiplier:** The multiplier is determined by the relevant regulatory authority and is not prescribed by the Ocean Accounts framework. Ocean Accounts provide the input data for the formula (extent and condition metrics) but do not set the multiplier. The illustrative example in this section uses a 2:1 multiplier, whilst the worked example in TG-1.6 Section 3.8 uses a regulator-specified 3:1 multiplier. Practitioners should apply the multiplier required by the applicable regulatory regime.

¶41 Applying a 2:1 multiplier (illustrative only) to account for implementation risk and time lag:

> *Offset = 5 ha × 0.80 × 2 = 8 ha-equivalents of seagrass at reference condition*

¶42 The **restoration equivalence unit** for delivery of the offset is defined as:

> *ha-equivalents delivered = (Restored area) × (Condition gain)*

¶43 where condition gain is the absolute increase in condition index achieved by the restoration action. Using this definition consistently with the requirement formula: restoration of 10 hectares of degraded seagrass from condition 0.60 to 0.80 delivers 10 × 0.20 = 2.0 ha-equivalents, which is insufficient to meet the 8 ha-equivalent requirement. Restoring 10 hectares from 0.50 to 0.80 (gain of 0.30) would deliver 10 × 0.30 = 3.0 ha-equivalents, still insufficient. The offset could instead be achieved through protection of 8 hectares of high-quality seagrass at risk of loss.

¶44 **Side-by-side equivalence check (illustrative seagrass example):**

Side	Formula	Values	Result
Requirement	Lost extent × Condition of lost habitat × Multiplier	5 ha × 0.80 × 2	8.0 ha-equivalents required
Delivery (option A)	Restored area × Condition gain	10 ha × 0.20 (from 0.60 to 0.80)	2.0 ha-equivalents delivered (shortfall)

Side	Formula	Values	Result
Delivery (option B)	Restored area × Condition gain	10 ha × 0.30 (from 0.50 to 0.80)	3.0 ha-equivalents delivered (shortfall)
Delivery (option C)	Area protected × Condition preserved	8 ha at reference condition	8.0 ha-equivalents (meets requirement)

¶45 Both sides of the equivalence calculation must use the same condition metric definition (absolute index points) to produce comparable results. Ecosystem service flow accounts enable assessment of whether proposed offsets adequately compensate for lost service flows, in addition to habitat area. If the 5 hectares of lost seagrass provided coastal stabilisation services valued at USD 2,000/ha/year and fish nursery services valued at USD 1,500/ha/year, the offset must provide equivalent service flows:

> *Required service compensation = 5 ha × USD 3,500/ha/year = USD 17,500/year*

¶46 The offsetting actions must demonstrably provide this level of service flow to achieve functional equivalence. Using the asset valuation approach set out above, the present value of the lost asset is:

> *Lost asset value = (Annual service flow) / (Discount rate) Lost asset value = USD 17,500 / 0.04 = USD 437,500*

¶47 This provides a quantitative basis for determining financial compensation where physical offsetting is not feasible.

¶48 **Temporal discounting of offset delivery:** Marine restoration offsets typically take 5–20 years to deliver the promised condition gain, whilst the impact occurs immediately. A nominal 1:1 equivalence at eventual full achievement understates the interim loss of ecosystem services during the restoration period. Some regulatory frameworks address this through temporal discounting provisions or by requiring upfront financial assurance (e.g., surety bonds or in-lieu fee arrangements) that compensate for the time lag. Practitioners should consult their applicable regulatory framework for guidance on whether temporal provisions apply. Where none exist, the multiplier (see above) partly serves this function by requiring over-delivery on the offset.

¶49 Time series data support assessment of whether offsets achieve their intended outcomes over the long term. Post-implementation monitoring should track condition variables and service flows using the same methods as the accounts. This supports objective assessment of offset success and triggers adaptive management responses if targets are not met.

¶50 Countries implementing marine offset policies should ensure that offset accounting is consistent with their broader Ocean Accounts framework to maintain coherence between project-level compensation and national ecosystem reporting [95].

¶51 The multiplier in the offset requirement is set by the regulator, not by the accounts. Ocean Accounts supply the extent and condition metrics on both sides of the equivalence; the policy parameters — multiplier, temporal discounting of delayed delivery, and whether financial compensation may substitute for physical offset — are matters for the applicable regulatory regime.

¶52 **Degradation**. In SEEA EA, ecosystem **degradation** represents the decline in condition multiplied by the associated loss of future ecosystem service flows, valued in monetary terms [96]. It is the ecosystem equivalent of depletion: the cost of using an ecosystem harder than it can sustain. The SEEA EA states that the approach "involves measuring the value of degradation in terms of loss in future value of ecosystem services due to a decline in ecosystem condition" [97]. For a policy-maker, degradation measures what ecosystem decline is costing the economy.

Recording losses from discrete events: catastrophic losses and conversions

¶53 A disaster — a cyclone, a mass bleaching event, an oil spill — is recorded differently from the gradual decline that degradation measures, and the two rules that govern it are the opposite of what intuition suggests.

¶54 **Physical accounts.** The treatment differs between the two account types, and conflating them is a common error. For **individual environmental assets** — fish stocks, timber, mineral resources — the SEEA CF physical asset account carries "Catastrophic losses" as a named line within reductions, covering "exceptional and significant reductions in the natural resource" that result from discrete events (SEEA CF para 5.49(c)). For **ecosystem extent accounts**, SEEA EA provides no standalone catastrophic-losses line: the reductions side is *managed contraction* and *unmanaged contraction*, and catastrophic losses are allocated between them according to whether the reduction was a deliberate management action, though SEEA EA notes they "could be separately identified" as a memorandum component. Report a disaster loss in an extent account as an identified component of unmanaged contraction, so the account still reconciles with the standard structure.

¶55 **A catastrophic loss is a loss of ecosystem *condition*, not of extent.** SEEA EA records under catastrophic losses the decreases in value due to "large-scale, discrete and recognizable events that cause a significant decline in the condition of an ecosystem asset, that is, significant losses in structure, function or composition", naming earthquakes, bushfires, cyclones and industrial disasters as the events in scope (paras 10.24, 10.37).

¶56 **Where the event changes the ecosystem type, it is a conversion.** "Where the effects of large-scale events are significant enough for the ecosystem to be considered to have changed its type, this should be recorded as an ecosystem conversion" (para 10.37). Mangrove stand that a cyclone destroys outright, leaving open water or bare mudflat, is a conversion, not a catastrophic loss.

What the event did	Recorded as
Reduced condition of a surviving ecosystem asset (structure, function, composition)	**Catastrophic losses**
Changed the ecosystem type at that location	**Ecosystem conversions**
Gradual condition decline from ongoing management and use	**Ecosystem degradation**

DRAFT

¶57 **Degradation is not the disaster line.** Degradation records decline in condition attributable to "the current and expected patterns of ecosystem management and use and expected patterns of environmental variation" (paras 10.22–10.23). A discrete, unforeseeable event is carved out of it precisely because its timing, location and magnitude cannot be anticipated. Routing disaster damage into degradation overstates the entry that feeds adjusted income measures.

¶58 The value recorded for a catastrophic loss is the fall in asset value attributable to the condition decline, derived through the same condition-to-service-flow-to-NPV chain as degradation, above. The value recorded for a conversion is the value of the converted extent, less any value of the ecosystem type that replaces it. Neither represents consumption of fixed capital or depletion: they reduce the value of the asset without arising from its use in production.

3.6 Produced Assets in the Ocean Domain

¶1 Whilst this Circular focuses primarily on environmental (non-produced) assets, ocean accounts must also include **produced assets** — the infrastructure, vessels, and equipment built for ocean-based activities. Produced assets are "assets that have come into existence as outputs of production processes" [98]. Recording them alongside environmental assets gives a full account of total ocean wealth and exposes the interdependencies between the two.

Types of produced assets in the ocean domain

¶1 Key categories include:

¶2 **Aquaculture fixed assets** — cages, pens, nets, and other infrastructure used for raising cultivated aquatic resources, as well as breeding stocks held as fixed assets [99]. These are produced assets resulting from deliberate investment decisions. For detailed guidance, see **TG-3.9 Aquaculture Accounts**.

¶3 **Offshore energy infrastructure** — platforms, drilling equipment, pipelines, subsea facilities for oil and gas extraction, as well as wind turbines, wave energy converters, and tidal energy devices for marine renewable energy. For detailed guidance, see **TG-3.10 Offshore Energy Accounts**.

¶4 **Port infrastructure** — wharves, jetties, breakwaters, dredged channels, container terminals, and other facilities for maritime transport and trade.

¶5 **Coastal protection structures** — sea walls, groynes, revetments, and other engineered structures designed to protect coastal areas from erosion and flooding. These can be considered alongside the natural coastal protection services provided by ecosystems such as mangroves and coral reefs [100]. Such comparisons often indicate that natural defences are more cost-effective than engineered ones.

¶6 **Vessels** — fishing vessels, cargo ships, cruise ships, offshore service vessels, and other maritime transport equipment.

Accounting treatment

¶1 Produced assets are accounted for following standard SNA methodology, with opening stocks, gross fixed capital formation (investment), consumption of fixed capital (depreciation), and closing stocks recorded in physical and monetary terms [101].

¶2 **Table 10: Produced asset account — structural template (after the SNA capital account)**

Accounting entry	Vessels	Aquaculture infrastructure	Offshore energy infrastructure	Port infrastructure	Coastal protection structures	Total
Opening stock (net)	[value]	[value]	[value]	[value]	[value]	[Σ]
Gross fixed capital formation	[value]	[value]	[value]	[value]	[value]	[Σ]
Consumption of fixed capital	[-value]	[-value]	[-value]	[-value]	[-value]	[-Σ]
Other changes in volume (incl. catastrophic loss)	[+/-]	[+/-]	[+/-]	[+/-]	[+/-]	[+/-]
Revaluation	[+/-]	[+/-]	[+/-]	[+/-]	[+/-]	[+/-]
Closing stock (net)	[value]	[value]	[value]	[value]	[value]	[Σ]
Memorandum: decommissioning provision	[value]	[value]	[value]	[value]	[value]	[Σ]

¶3 *Table 10: Structural template of a produced asset account for the ocean domain. Compiled on standard SNA methodology [101]; the decommissioning memorandum is specific to the ocean domain, where offshore energy and aquaculture infrastructure carry retirement obligations that the net stock does not show. Its treatment is in TG-3.10 Offshore Energy Accounts Section 3.6.*

¶4 For ocean accounting, produced assets interact with environmental assets in three ways:

- ¶5 Aquaculture investment creates produced assets (infrastructure) that depend on environmental assets (water quality, marine ecosystems providing supporting services). If the environmental asset degrades, the produced asset becomes less productive.
- ¶6 Offshore oil and gas investment creates produced assets that enable extraction of environmental assets (mineral resources). The produced asset depreciates through use, whilst the environmental asset depletes through extraction.
- ¶7 Coastal infrastructure may protect inland assets but may also affect coastal ecosystem extent and condition — a sea wall can prevent erosion of property whilst destroying the beach ecosystem in front of it.

¶8 These connections should be reflected in integrated accounts that present produced and environmental assets together, enabling analysis of total ocean wealth and its composition. Combined presentations of environmental and economic accounts are addressed in **TG-3.8 Combined Presentations**.

3.7 Worked Example: Coastal Ecosystem Asset Accounts

¶1 This section demonstrates how to compile physical and monetary asset accounts for a hypothetical coastal area. The example uses synthetic data for three marine ecosystem types (mangroves, seagrass meadows, and continental shelf waters) and one individual environmental asset (fish stocks), following the compilation procedure from Section 3.2 and the account structures from Sections 3.4 and 3.5. Working through this example demonstrates how the components combine, and how physical declines can be masked by monetary gains.

Scenario description

¶1 The accounting area is a coastal zone extending 12 nautical miles offshore and encompassing 500 km² of mangrove forest, 200 km² of seagrass meadows, and 15,000 km² of continental shelf marine waters. The area supports commercial fisheries targeting demersal fish species that depend on mangroves and seagrass as nursery habitat. The accounting period is calendar year 2025.

Step 1: Ecosystem extent accounts

¶1 Extent data were compiled from Sentinel-2 satellite imagery processed using supervised classification algorithms, validated by field surveys at 150 ground-truth sites (see **TG-4.1 Remote Sensing and Geospatial Data**). Change detection analysis identified conversions between ecosystem types and losses to non-natural land cover.

¶2 **Physical extent account (area in km²)**

Accounting entry	Mangroves	Seagrass	Shelf Waters	Total
Opening extent (1 Jan 2025)	500	200	15,000	15,700
Additions to extent				
Managed expansion (restoration)	2.5	1.2	0	3.7
Natural expansion	0.8	0.3	0	1.1
Total additions	3.3	1.5	0	4.8
Reductions in extent				
Managed reduction (conversion to aquaculture)	4.0	0.5	0	4.5
Natural reduction (storm damage, erosion)	2.5	1.8	0	4.3
Total reductions	6.5	2.3	0	8.8
Net change in extent	-3.2	-0.8	0	-4.0
Closing extent (31 Dec 2025)	496.8	199.2	15,000	15,696

¶3 *Table 5: Physical ecosystem extent account for coastal zone, 2025*

¶4 **Reading the account.** The coastal zone lost 3.2 km² of mangroves and 0.8 km² of seagrass during 2025. Managed reductions (conversion to aquaculture ponds) exceeded managed expansion (restoration projects): deliberate human decisions drove more loss than restoration could offset. Natural reductions from storm damage and coastal erosion added to the deficit. Continental shelf waters recorded no change in extent because the accounting area boundary remained fixed.

DRAFT

Step 2: Ecosystem condition accounts

¶1 Condition data were compiled from 45 monitoring stations distributed across the three ecosystem types, measuring variables in each of the six ECT classes. Measurements were taken quarterly and averaged for the year.

¶2 **Condition variable account for mangroves (selected variables)**

ECT class	Variable	Unit	Polarity	Lower reference *L*	Upper reference *U*	Opening value	Closing value
A1 Physical state	Sedimentation rate	mm/yr	Inverse	8.0	2.0	3.2	3.5
A2 Chemical state	Soil salinity	PSU	Inverse	35	15	18	19
B1 Compositional state	Tree species richness	count	Normal	2	12	8	8
B2 Structural state	Canopy density	% cover	Normal	20	85	72	70
B3 Functional state	Leaf litter production	g/m²/yr	Normal	150	550	480	465
C1 Landscape/seascape	Connectivity index	0–1	Normal	0.20	0.80	0.68	0.65

¶3 *Table 6: Ecosystem condition variable account for mangroves, 2025, in the Table 3a format*

¶4 **Reading the account.** Every variable sits between its two reference levels, and all but species richness are moving towards the lower one. Canopy density dropped from 72% to 70% against an upper reference of 85%. Connectivity between mangrove patches fell from 0.68 to 0.65, likely because the conversion of mangrove patches to aquaculture created gaps in the landscape. Leaf litter production, a proxy for ecosystem productivity, declined from 480 to 465 g/m²/yr.

¶5 **Condition indicator account.** Each variable is rescaled on its own reference levels using the transformation in **TG-2.1** Section 3.4.1 — `(V - L) / (U - L)` for normal polarity, `(L - V) / (L - U)` for inverse.

ECT class	Condition indicator	Opening	Closing	Change	Data tier
A1 Physical state	Sedimentation	0.80	0.75	-0.05	2
A2 Chemical state	Soil salinity	0.85	0.80	-0.05	2
B1 Compositional state	Tree species richness	0.60	0.60	0.00	1

ECT class	Condition indicator	Opening	Closing	Change	Data tier
B2 Structural state	Canopy density	0.80	0.77	-0.03	1
B3 Functional state	Leaf litter production	0.83	0.79	-0.04	2
C1 Landscape/seascape	Connectivity	0.80	0.75	-0.05	2

¶6 *Table 6a: Ecosystem condition indicator account for mangroves, 2025, in the Table 3b format*

¶7 Worked for one row: canopy density is normal polarity with L = 20% and U = 85%, so the closing indicator is (70 - 20) / (85 - 20) = 50 / 65 = 0.77.

¶8 **Condition index.** Aggregated as an unweighted arithmetic mean of the six class indicators — the publication default in **TG-2.1** Section 3.6. With one indicator per class the class sub-index equals the indicator.

Level	Component	Weight	Opening	Closing	Change
Class sub-index	A1 Physical state	1/6	0.80	0.75	-0.05
Class sub-index	A2 Chemical state	1/6	0.85	0.80	-0.05
Class sub-index	B1 Compositional state	1/6	0.60	0.60	0.00
Class sub-index	B2 Structural state	1/6	0.80	0.77	-0.03
Class sub-index	B3 Functional state	1/6	0.83	0.79	-0.04
Class sub-index	C1 Landscape/seascape	1/6	0.80	0.75	-0.05
Mangrove condition index	**All classes**	—	**0.78**	**0.74**	**-0.04**

¶9 *Table 6b: Ecosystem condition index for mangroves, 2025, in the Table 3c format*

¶10 The mangrove condition index fell 0.04 index points over the year. That figure — not a judgement about the variables — is what the degradation entry in Step 4 consumes. Had the aggregation rule been one-out-all-out rather than the arithmetic mean, the index would have been 0.60 in both periods and the change zero, because species richness is both the worst indicator and the only stable one. The rule is doing real work, which is why Section 3.5.2 requires it to be recorded in the account.

Step 3: Fish stock asset account

¶1 Fish stock data were compiled from stock assessment models for the dominant demersal species complex, using data from commercial catch statistics, fishery-independent trawl surveys, and length-frequency analysis. The stock assessment estimated total biomass, natural mortality, recruitment, and fishing mortality using age-structured models.

¶2 **Physical asset account for fish stocks (biomass in tonnes)**

DRAFT

Accounting entry	Value
Opening stock (1 Jan 2025)	42,000
Additions to stock	
Natural growth (recruitment + growth)	8,500
Upward reappraisals	0
Total additions	8,500
Reductions in stock	
Gross catch (commercial fisheries)	7,200
Natural mortality	4,800
Catastrophic losses (fish kill from hypoxia event)	500
Total reductions	12,500
Closing stock (31 Dec 2025)	38,000
Derived measures	
Sustainable yield (MSY estimate)	6,500
Depletion (catch - sustainable yield)	700

¶3 *Table 7: Physical asset account for demersal fish stock, 2025*

¶4 **Reading the account.** The fish stock declined by 4,000 tonnes (9.5%) during 2025. Gross catch of 7,200 tonnes exceeded the sustainable yield estimate of 6,500 tonnes by 700 tonnes. That 700 tonnes is depletion, the amount by which the fishery is drawing down its capital base. The stock also experienced a catastrophic loss of 500 tonnes from a hypoxia event in coastal waters during summer, potentially linked to the nutrient loading and habitat fragmentation recorded in the mangrove condition data. The decline was driven by the combination of overfishing and environmental stress.

Step 4: Monetary valuation

¶1 Monetary values were estimated for ecosystem assets using the NPV of expected future ecosystem service flows, and for fish stocks using the NPV of expected future resource rents.

¶2 **Mangrove ecosystem services valuation** (values expressed per km² for this illustrative example):

- ¶3 Coastal protection service: Replacement cost method based on equivalent seawall construction, estimated at USD 12,000 per km² per year

- ¶4 Carbon sequestration service: Social cost of carbon (USD 50 per tonne CO2) applied to sequestration rate, USD 400 per km² per year
- ¶5 Fish nursery service: Productivity change method estimating contribution to commercial fisheries, USD 800 per km² per year
- ¶6 Total annual ecosystem service value: USD 13,200 per km² per year
- ¶7 Discount rate: 4% real
- ¶8 Asset value (perpetual annuity): USD 13,200 / 0.04 = USD 330,000 per km² (equivalent to USD 3,300 per hectare)

¶9 **Seagrass ecosystem services valuation** (values expressed per km²):

- ¶10 Carbon sequestration: USD 300/km²/yr
- ¶11 Water filtration: Avoided treatment cost USD 150/km²/yr
- ¶12 Fish nursery: USD 600/km²/yr
- ¶13 Total annual service value: USD 1,050/km²/yr
- ¶14 Asset value (4% discount): USD 1,050 / 0.04 = USD 26,250 per km² (equivalent to USD 262.5 per hectare)

¶15 **Fish stock valuation**:

- ¶16 Resource rent per tonne caught: USD 450 (gross value of landings USD 1,200/tonne, less all costs)
- ¶17 Sustainable yield: 6,500 tonnes/yr
- ¶18 Annual sustainable resource rent: 6,500 x USD 450 = USD 2,925,000
- ¶19 Asset value (4% discount, perpetual): USD 2,925,000 / 0.04 = USD 73,125,000

¶20 **Monetary ecosystem asset account (values in USD thousand)**

Accounting entry	Mangroves	Seagrass	Total
Opening value (500 km² x USD 3,300/ha; 200 km² x USD 262.5/ha)	165,000	5,250	170,250
Ecosystem enhancement (condition improvement from restoration, 2.5 km²)	825	0	825
Ecosystem degradation (condition index decline x opening value)	-6,600	-105	-6,705
Ecosystem conversions (additions)	0	0	0
Ecosystem conversions (reductions: -4.0 km², -0.5 km²)	-1,320	-13	-1,333
Catastrophic losses (storm damage value loss)	-825	-47	-872
Reappraisals	0	0	0
Revaluation (5% increase in unit service values)	8,250	263	8,513
Net change in value	**330**	**98**	**428**
Closing value	165,330	5,348	170,678

¶21 *Table 8: Monetary ecosystem asset account, 2025*

¶22 **Where the degradation entry comes from.** The mangrove figure is the condition index decline from Table 6b applied to the opening asset value, following Section 3.5.3: 0.04 x USD 165,000 thousand = USD 6,600 thousand. The seagrass figure is the same calculation on a parallel condition account not reproduced here, whose index fell 0.02 points: 0.02 x USD 5,250 thousand = USD 105 thousand. Both fall inside the applicability conditions for the simplified linear approximation set out in Section 3.5.3 — the decline is well under 0.20 index points, no threshold response is documented for these ecosystem types in this range, and coastal protection accounts for over 70 per cent of the mangrove service value per hectare. A compiler whose condition decline is larger, or whose asset value is split across services that respond differently, must use the service-specific route instead.

¶23 **Fish stock monetary asset account (values in USD thousand)**

Accounting entry	Value
Opening value (1 Jan 2025)	73,125
Additions (natural growth valued at resource rent/tonne)	3,825
Reductions (extraction and mortality)	-5,400
Catastrophic losses (hypoxia event)	-225
Reappraisals (revised sustainable yield estimate)	0
Revaluation (10% increase in fish prices)	7,313
Closing value (31 Dec 2025)	78,638

¶24 *Table 9: Monetary fish stock asset account, 2025*

¶25 **Reading the account — and what it can obscure.** Holding gains do most of the work in this account. For mangroves, a 5% increase in unit service values (driven by updated coastal protection valuations following storm damage in a neighbouring region) generated USD 8.25 million, enough to more than offset USD 6.6 million of degradation, USD 1.32 million of conversion loss and USD 0.83 million of catastrophic loss, and to leave the mangrove closing value USD 0.33 million *above* its opening value. For fish stocks, a 10% price increase generated USD 7.3 million, more than offsetting the value of depletion, so that account too closes higher than it opened.

¶26 Strip the revaluations out and the picture inverts. Mangroves lose USD 7.92 million at constant prices; the ecosystem account as a whole loses USD 8.09 million rather than gaining the USD 0.43 million the closing line reports; and the fish stock loses USD 1.80 million rather than gaining USD 5.51 million. The physical accounts said as much all along — declining fish stocks, shrinking mangroves, a condition index down 0.04 points — and it is the price column, not the ecosystem, that is carrying the closing balance.

DRAFT

¶27 This is why the decomposition is not optional. Adjusted income measures should deduct depletion and degradation at constant prices, and changes in asset value due to price effects must be reported separately as revaluations rather than as real income. The SEEA CF requires depletion to be valued at the average of opening and closing prices to give a neutral mid-period valuation[36]. An account that reports only opening and closing values, without the revaluation line, is capable of showing growth through an entire period of ecosystem collapse.

Step 5: Integration and policy implications

¶1 The worked example demonstrates several key linkages in the ocean accounting system:

¶2 **Upward linkages to policy (TG-1.x and TG-2.x)**:

- ¶3 **TG-1.1 National Ocean Budgets**: The USD 6,705 thousand in ecosystem degradation plus USD 315 thousand in fish stock depletion (700 tonnes above sustainable yield at USD 450/tonne resource rent, for a total of USD 7,020 thousand at constant prices) represents the natural capital cost of economic activity during 2025. This cost should be deducted from gross income measures to calculate environmentally adjusted net domestic product.
- ¶4 **TG-2.1 Aggregate Biophysical Indicators of Environmental State**: The 0.025% decline in ecosystem extent (4.0 km² loss from 15,700 km² total) and 9.5% decline in fish stock biomass provide headline indicators of environmental state for policy monitoring.
- ¶5 **TG-2.4 Ecosystem Goods and Services**: The estimated ecosystem service flows (coastal protection, carbon sequestration, fish nursery) quantified in the valuation step provide inputs to ecosystem service accounts.

¶6 **Downward linkages to data (TG-4.x)**:

- ¶7 **TG-4.1 Remote Sensing and Geospatial Data**: Sentinel-2 imagery provided the primary data source for extent change detection.
- ¶8 **TG-4.2 Survey Methods for Ocean Economic Activity**: Field monitoring at 45 stations provided condition variable measurements. In-situ data remains necessary to complement remote sensing.
- ¶9 **TG-4.3 Administrative Data Sources**: Integration of extent, condition, and stock assessment data within a common spatial framework enabled consistent attribution of ecosystem services to ecosystem assets and analysis of nursery habitat contributions to fisheries.

¶10 **Cross-account consistency**:

- ¶11 Fish stock depletion of 700 tonnes corresponds to extraction recorded in physical supply-use tables (see **TG-3.2 Flows from Environment to Economy**)
- ¶12 Ecosystem extent changes are reconciled with ecosystem conversion matrices
- ¶13 Monetary degradation and depletion entries correspond to physical condition decline and stock reduction multiplied by appropriate unit values

¶14 This worked example illustrates how asset accounts provide a structured framework for organising diverse data sources, maintaining accounting identities that ensure internal consistency, and deriving policy-relevant measures of sustainability. The procedure can be scaled to national accounting areas and extended to additional asset types following the same logical structure.

DRAFT

Implementation Considerations

¶1 For minimum institutional capacity, data infrastructure, and human skills requirements for compiling these accounts, see TG-0.8 Implementation Readiness Assessment. For guidance on adapting these methods to sub-national scales, see TG-3.11 Sub-National Ocean Accounts.

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

FOOTNOTES

1. ¶1 SEEA CF, para 5.42. "Asset accounts record both the opening and the closing stock of assets and the changes over the accounting period."
2. ¶2 SEEA CF, para 5.43
3. ¶3 SEEA CF, para 5.44
4. ¶4 SEEA CF, para 5.72. For renewable biological resources, "natural growth relates to the number of animals… or volume of plants… that have been added to the stock due to natural processes."
5. ¶5 SEEA CF, para 5.82. "For any given population, it is possible to calculate the number of animals or volume of plants by age or size class that may be removed from the population without affecting the capacity of the population to regenerate itself."
6. ¶6 SEEA CF, para 5.180
7. ¶7 SEEA CF, para 5.51. "Reappraisals record changes in estimates of the stock due to revisions in the estimation techniques being applied."
8. ¶8 SEEA CF, para 5.458
9. ¶9 SEEA CF, para 5.52
0. ¶10 SEEA CF, para 5.422
1. ¶11 SEEA CF, para 5.47
2. ¶12 SEEA CF, para 5.429
3. ¶13 SEEA CF, para 5.428
4. ¶14 SEEA CF, para 5.48
5. ¶15 SEEA CF, para 5.50
6. ¶16 SEEA CF, para 2.107
7. ¶17 SEEA CF, Annex A5.1, para A5.28-A5.31
8. ¶18 2025 SNA, Chapter 11, para 11.45
9. ¶19 SEEA CF, para 5.431
0. ¶20 SEEA CF, Chapter 5, Table 5.1. Classification of environmental assets.

1. ¶21 SEEA EA, Table 4.1 and para 4.10–4.22. Ecosystem extent account structure and accounting entries.
2. ¶22 SEEA CF, para 5.103–5.111
3. ¶23 2025 SNA, Chapter 13, paras 13.1–13.15. Balance sheets record stocks of assets and liabilities, with net worth = assets - liabilities.
4. ¶24 SEEA CF, para 5.96
5. ¶25 SEEA CF, para 5.97
6. ¶26 SEEA CF, para 5.102
7. ¶27 SEEA CF, para 5.103–5.111
8. ¶28 SEEA CF, para 5.110. "Net present value is the value of an asset determined by estimating the stream of income expected to be earned in the future and then discounting the future income back to the present accounting period."
9. ¶29 SEEA CF, Annex A5.1, para A5.15
0. ¶30 SEEA CF, Annex A5.2, para A5.42–A5.76
1. ¶31 SEEA CF, Annex A5.2, paras A5.42–A5.76. Discusses discount rate selection including the use of a rate "at the higher end of the range of observable rates on government and high-quality corporate bonds" adjusted for asset-specific risk.
2. ¶32 SEEA CF, para 5.444–5.452
3. ¶33 SEEA CF, para 5.448
4. ¶34 SEEA EA, para 12.30–12.39
5. ¶35 SEEA CF, Annex A5.1, para A5.31
6. ¶36 SEEA CF, Annex A5.1, para A5.27
7. ¶37 SEEA CF, para 5.11
8. ¶38 SEEA CF, para 5.393
9. ¶39 SEEA CF, para 5.395
0. ¶40 SEEA CF, para 5.420–5.422
1. ¶41 SEEA CF, para 5.423
2. ¶42 SEEA CF, para 5.425
3. ¶43 SEEA CF, para 5.457
4. ¶44 SEEA CF, para 5.429
5. ¶45 SEEA CF, para 5.429
6. ¶46 SEEA CF, Table 5.22
7. ¶47 SEEA CF, para 5.436
8. ¶48 Physical asset account template integrating SEEA CF Table 5.4 (general structure of physical asset accounts for environmental assets), SEEA EA Table 4.1 (ecosystem extent account), and SEEA CF Table 5.22 (aquatic resources account).
9. ¶49 SEEA CF, para 5.431–5.432
0. ¶50 SEEA CF, para 5.431
1. ¶51 SEEA CF, para 5.433
2. ¶52 SEEA CF, para 5.434
3. ¶53 SEEA CF, para 5.435
4. ¶54 SEEA CF, para 5.436
5. ¶55 SEEA CF, para 5.442
6. ¶56 SEEA CF, para 5.450
7. ¶57 SEEA CF, para 5.443
8. ¶58 SEEA CF, para 5.173
9. ¶59 SEEA CF, para 5.175–5.178
0. ¶60 SEEA CF, para 5.182–5.183
1. ¶61 SEEA CF, para 5.113–5.114. "Resource rent is the economic rent that accrues in relation to environmental assets, including natural resources."
2. ¶62 SEEA CF, para 5.474
3. ¶63 SEEA CF, para 5.476
4. ¶64 SEEA CF, para 5.469
5. ¶65 SEEA EA, para 2.6
6. ¶66 SEEA EA, para 2.11
7. ¶67 SEEA EA, para 4.1
8. ¶68 SEEA EA, para 4.10. "The structure of the rows reflects the general logic of asset accounts as described in the SEEA Central Framework."
9. ¶69 SEEA EA, Table 4.1
0. ¶70 UN SEEA EA (2021), paras 4.10–4.13 and Table 4.1. The row structure of the extent account follows the general asset-account logic of the SEEA Central Framework (opening stock, additions, reductions, closing stock); columns correspond to the classes of the selected ecosystem type classification.
1. ¶71 UN SEEA EA (2021), para 4.15. Definitions of opening/closing extent, managed and unmanaged expansions, and managed and unmanaged reductions. The accounting identity that the sum of areas of all ecosystem types equals the total area of the EAA is stated in para 4.13.
2. ¶72 UN SEEA EA (2021), paras 4.14 (minimum-detail recording where managed/unmanaged split is unavailable) and 4.17 (treatment of revisions arising from updated input data or methods; no distinct revision entry recorded).
3. ¶73 SEEA EA, para 4.23
4. ¶74 SEEA EA, para 3.32
5. ¶75 SEEA EA, para 3.32
6. ¶76 IUCN GET, M1 Marine Shelf biome
7. ¶77 SEEA EA, para 2.13
8. ¶78 SEEA EA, para 5.5–5.8
9. ¶79 SEEA EA, para 5.15–5.25
0. ¶80 SEEA EA, para 3.35
1. ¶81 SEEA EA, para 5.32, Table 5.1
2. ¶82 SEEA EA, Figure 6.1 and para 6.18. The capacity to deliver ecosystem services is a function of both the extent and the condition of the ecosystem asset.
3. ¶83 SEEA EA, Table 5.1. Ecosystem Condition Typology (ECT) classes for organising condition characteristics.
4. ¶84 SEEA EA, para 5.46. "Ideally, the compilation of ecosystem condition accounts should ensure that for each ecosystem type, at least one variable is selected for each of the six ECT classes."
5. ¶85 SEEA EA, para 5.47. "A set of about 6 to 10 well-selected indicators for a given ecosystem type should provide sufficient information to assess the overall condition of an ecosystem asset."
6. ¶86 SEEA EA, Table 5.7. Indicative set of ecosystem condition variables for biomes structured in accordance with the ECT.
7. ¶87 SEEA EA, para 5.35–5.48
8. ¶88 SEEA EA, para 5.10
9. ¶89 SEEA EA, Chapter 10
0. ¶90 SEEA EA, Chapter 10, Table 10.1, paras 10.7–10.12. The monetary ecosystem asset account records the NPV of ecosystem services supplied by each ecosystem type.

DRAFT

1. ¶91 SEEA EA, paras 10.15–10.41. Definitions of ecosystem enhancement (para 10.15), ecosystem degradation (para 10.21), ecosystem conversions (para 10.30), other changes in volume (para 10.36), and revaluations (para 10.41).
2. ¶92 SEEA EA, paras 10.36–10.39. Catastrophic losses are "large-scale, discrete and recognizable events that cause a significant loss in the condition of an ecosystem asset" (para 10.37). Reappraisals record changes due to "updated information that permits a reassessment of the expected condition of the ecosystem assets or the future demand for ecosystem services" (para 10.38).
3. ¶93 SEEA EA, para 10.41. "Revaluations are changes in the value of ecosystem assets over an accounting period that are due solely to movements in the unit prices of ecosystem services."
4. ¶94 United Nations Environment Programme (2022). *Guidelines on Biophysical Modelling for Ecosystem Accounting*. UNEP, Nairobi. Provides methods for assessing ecosystem capacity and identifying threshold responses where the linear approximation is not appropriate.
5. ¶95 Countries implementing marine offset policies should ensure that offset accounting is consistent with their broader Ocean Accounts framework, so that project-level compensation and national ecosystem reporting remain coherent.
6. ¶96 SEEA EA, para 11.25
7. ¶97 SEEA EA, para 12.30
8. ¶98 SEEA CF, para 5.34
9. ¶99 SEEA CF, para 5.395
0. ¶100 SEEA EA, para 6.55 on coastal protection as an ecosystem service
1. ¶101 2025 SNA, Chapter 13

DRAFT

Flows from Environment to Economy

Compiles accounts for flows from the environment to the economy in the context of ocean accounting.

Version 0.8.2 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

OUTCOME

After completing this Circular, readers will be able to compile accounts for flows from the environment to the economy in the context of ocean accounting. These flows encompass ecosystem services (the contributions that marine and coastal ecosystems make to benefits used in economic and other human activity) as well as natural resource inputs extracted from the ocean environment. Understanding and measuring these flows is essential for three purposes: revealing the economic dependencies on ocean ecosystems, informing sustainable management of marine resources, and integrating environmental considerations into economic decision-making.
Section 3.3 includes a worked example tracing which supply-use and extent-account entries change under a spatial conversion scenario, of the kind evaluated in marine spatial planning.
For policy analysis, these accounts answer questions such as: What is the annual value of coastal protection provided by coral reefs and mangroves? How much fish biomass is being extracted relative to the ecosystem's capacity to supply it? What proportion of national tourism activity depends on marine ecosystem services? Which industries and communities are most dependent on flows from marine ecosystems, and therefore most exposed to ecosystem degradation? By compiling the accounts described in this Circular, countries can measure the flows that connect ocean ecosystems to economic production and human well-being. These accounts support indicators such as ecosystem dependency ratios (see TG-2.3 Social and Livelihood Dependencies) and environmental goods and services indicators (see TG-2.4 Ecosystem Goods and Services).
This Circular covers (1) the classification and measurement of provisioning, regulating, and cultural ecosystem services in marine contexts, (2) the treatment of natural resource inputs such as fish, water, and energy, (3) the compilation procedure for physical supply and use tables (PSUTs) for ecosystem services, (4) worked examples with synthetic data for coastal zones, and (5) approaches to the monetary valuation of flows from environment to economy. For the treatment of flows from economy to environment (residuals, emissions, waste), see TG-3.4 Flows from Economy to Environment.

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 4
3.1 Ecosystem Services 4
3.2 Natural Resource Inputs 11
3.3 Physical Supply and Use Tables: Structure and Compilation Procedure 16
3.4 Worked Example: Coastal Zone Ecosystem Services Account 23
3.5 Monetary Valuation of Flows 26
Implementation Considerations 30
4. Acknowledgements 30
Footnotes 30

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Flows from Environment to Economy (2026) (GOAP Technical Guidance on Ocean Accounting, TG-3.2, v0.8.2). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-3/3-2-flows-env-econ/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

1. Outcome

¶1 After completing this Circular, readers will be able to compile accounts for flows from the environment to the economy in the context of ocean accounting. These flows encompass ecosystem services (the contributions that marine and coastal ecosystems make to benefits used in economic and other human activity) as well as natural resource inputs extracted from the ocean environment. Understanding and measuring these flows is essential for three purposes: revealing the economic dependencies on ocean ecosystems, informing sustainable management of marine resources, and integrating environmental considerations into economic decision-making [1].

¶2 Section 3.3 includes a worked example tracing which supply-use and extent-account entries change under a spatial conversion scenario, of the kind evaluated in marine spatial planning.

¶3 For policy analysis, these accounts answer questions such as: What is the annual value of coastal protection provided by coral reefs and mangroves? How much fish biomass is being extracted relative to the ecosystem's capacity to supply it? What proportion of national tourism activity depends on marine ecosystem services? Which industries and communities are most dependent on flows from marine ecosystems, and therefore most exposed to ecosystem degradation? By compiling the accounts described in this Circular, countries can measure the flows that connect ocean ecosystems to economic production and human well-being. These accounts support indicators such as ecosystem dependency ratios (see **TG-2.3 Social and Livelihood Dependencies**) and environmental goods and services indicators (see **TG-2.4 Ecosystem Goods and Services**).

¶4 This Circular covers (1) the classification and measurement of provisioning, regulating, and cultural ecosystem services in marine contexts, (2) the treatment of natural resource inputs such as fish, water, and energy, (3) the compilation procedure for physical supply and use tables (PSUTs) for ecosystem services, (4) worked examples with synthetic data for coastal zones, and (5) approaches to the monetary valuation of flows from environment to economy. For the treatment of flows from economy to environment (residuals, emissions, waste), see **TG-3.4 Flows from Economy to Environment**.

DRAFT

2. Requirements

¶1 **Essential prerequisites:**

- ¶2 **TG-0.1 General Introduction to Ocean Accounts**: conceptual framework connecting ecosystems to economic activity
- ¶3 **TG-3.1 Asset Accounts**: relationship between ecosystem assets and the services they supply

¶4 **Helpful background:**

- ¶5 **TG-2.4 Environmental (including Ecosystem) Goods and Services** Section 3.10: valuation methods referenced throughout this Circular
- ¶6 **TG-0.7 Quality Assurance Principles**: quality assurance principles for the compiled accounts

¶7 **Framework Position**

¶8 This Circular addresses the flows from marine and coastal ecosystems to human activities: ecosystem services flowing to the economy (E9), ecosystem services flowing to society beyond market transactions (E10), and intermediate ecological processes that maintain ecosystem functioning (E11). In the Ocean Accounts Framework (TG-0.1 Figure 0.1.2):

Edge	Direction	Description
E9	SG3 → FG1	Ecosystem services to economy (Applied)
E10	SG3 → FG2	Ecosystem services to society beyond the economy (Emerging)
E11	FG3 ↔ SG3	Intermediate ecosystem services and ecological processes (Applied)

¶9 **Scope.** TG-3.2 owns the supply and use tables for flows from the environment to the economy — the ecosystem services supply-use table and the natural resource inputs table — together with the ecosystem type change matrix that links them to extent. It cross-refers for the ecosystem-specific service method to Section 6 (**TG-6.1**, **TG-6.2**, **TG-6.3**, **TG-6.5**), for measurement of the service quantities to Section 4, for the valuation method applied to a service to **TG-2.4** Section 3.10, and for the asset the services are capitalised into to **TG-3.1**.

3. Guidance Material

¶1 Flows from the environment to the economy are the channel through which ocean ecosystems contribute to human well-being and economic production[2]. The SEEA framework distinguishes two main categories of such flows: ecosystem services, which are the contributions of ecosystem assets to benefits, and natural resource inputs, which are physical materials extracted from the environment for use in economic processes[3]. Both categories are essential for ocean accounting. Marine ecosystem services include fish provisioning, coastal protection, carbon sequestration, and recreation, whilst natural resource inputs include harvested fish, abstracted seawater, and extracted seabed minerals.

¶2 This section examines ecosystem services in the marine context (Section 3.1), natural resource inputs (Section 3.2), the structure and compilation procedure for physical supply and use tables (Section 3.3), worked examples for coastal zone accounts (Section 3.4), and approaches to monetary valuation of flows from environment to economy (Section 3.5). The methodology presented here provides the basis for measuring the contributions that ocean ecosystems make to the economy and society. It supports the compilation of accounts for indicators of ecosystem dependency (**TG-2.3 Ecosystem Dependency Indicators**) and analysis of ecosystem goods and services (**TG-2.4 Ecosystem Goods and Services**). Measuring these flows draws on the spatial data sources described in **TG-4.1 Remote Sensing and Geospatial Data** and the survey methodologies presented in **TG-4.2 Survey Methods for Ocean Economic Activity**.

3.1 Ecosystem Services

¶1 Ecosystem services are the contributions of ecosystems to the benefits that are used in economic and other human activity[4]. The SEEA Ecosystem Accounting framework defines ecosystem services as flows between ecosystem assets and economic units, where economic units encompass businesses, governments, and households[5]. In the marine context, ecosystem services include the provision of fish and other harvested biomass, the regulation of climate through carbon sequestration, the protection of coastlines from storms and erosion, the filtration and purification of water, and the provision of recreational and cultural experiences.

Classification of ecosystem services

¶1 The SEEA EA presents a reference list of ecosystem services organised into three main sections[6], summarised in Table 3.1.1 below.

DRAFT

Service category	Description
Provisioning services	Ecosystem contributions to the growth of biomass and other materials that can be harvested or extracted for use in economic activity.
Regulating and maintenance services	Ecosystem contributions that regulate or maintain environmental conditions that benefit people.
Cultural services	The experiential and intangible contributions of ecosystems that support physical, intellectual, and spiritual well-being.

¶2 This classification builds upon and is compatible with the Common International Classification of Ecosystem Services (CICES)[7], which provides a hierarchical structure for ecosystem service classification. For ocean accounting, each category has particular relevance. A summary of key marine ecosystem services and their classification is presented in Table 1.

Service Category	Ecosystem Service	Key Marine Ecosystem Types	Typical Units
Provisioning	Fish provisioning	Marine shelf, pelagic	tonnes biomass
	Aquaculture provisioning	Coastal, marine shelf	tonnes biomass
	Seaweed/algae provisioning	Coastal, rocky shores	tonnes biomass
Regulating and maintenance	Global climate regulation	All marine, esp. blue carbon	tonnes carbon
	Coastal protection	Coral reefs, mangroves, seagrass	hectares protected
	Water purification	Coastal wetlands, seagrass	volumes filtered
	Nursery habitat*	Mangroves, seagrass, estuaries	hectares habitat
Cultural	Recreation	Coral reefs, beaches, MPAs	visitor-days
	Visual amenity	Coastal seascapes	hedonic value

¶3 *Table 1: Selected marine ecosystem services by category (adapted from SEEA EA Table 6.3)[8]. *Nursery habitat is a potentially intermediate service (see Section 3.1 on nursery services); compilers should take care to avoid double counting with provisioning services.*

¶4 For the full list of marine-relevant ecosystem services, compilers should consult SEEA EA Table 6.3. Table 1b below provides an expanded reference mapping all SEEA EA services to ocean relevance.

Ecosystem services by ecosystem type: a worked example

¶1 To illustrate how ecosystem services vary across marine and coastal ecosystem types, Table 1a presents a worked example mapping selected ecosystem services to four representative ecosystem types. Compilers are encouraged to develop similar mappings for their accounting area, following the SEEA EA Technical Recommendations guidance to "create a table showing which ecosystem services are likely to be supplied from different ecosystem types for their country or target ecosystem accounting area"[9]. The services listed below follow the three categories defined in SEEA EA Table 6.3: provisioning services, regulating and maintenance services, and cultural services[10].

¶2 **Table 1a: Illustrative ecosystem services by marine ecosystem type**

Ecosystem Service	Mangroves	Coral Reefs	Seagrass Meadows	Open Marine Pelagic
Provisioning services				
Biomass provisioning (wood)	Timber and fuelwood harvest	–	–	–

DRAFT

Ecosystem Service	Mangroves	Coral Reefs	Seagrass Meadows	Open Marine Pelagic
Wild fish and other aquatic biomass provisioning	Inshore fish, crabs, shellfish	Reef fish, lobster, sea cucumber	Fish, shellfish associated with seagrass beds	Pelagic fish (tuna, mackerel, sardines)
Aquaculture provisioning	Shrimp ponds in mangrove areas	–	–	Offshore cage aquaculture
Genetic material services	Bioactive compounds from mangrove species	Genetic resources from coral reef organisms	–	Marine genetic resources from open-ocean species
Regulating and maintenance services				
Global climate regulation	High carbon sequestration and long-term storage in soils	Limited direct sequestration; reef calcification affects CO2	Carbon sequestration and storage in sediments	Ocean CO2 uptake by phytoplankton
Coastal protection (flood control)	Wave and storm surge attenuation	Wave breaking and energy dissipation	Wave attenuation and sediment stabilisation	–
Water purification	Nutrient filtration and sediment trapping	–	Nutrient uptake and sediment trapping	–
Nursery population and habitat maintenance	Critical nursery habitat for fish and crustaceans	Shelter and feeding habitat for juvenile reef species	Nursery and feeding grounds for fish and invertebrates	Spawning and migration habitat for pelagic species
Soil erosion control	Shoreline stabilisation through root systems	Breakwater function reducing shoreline erosion	Sediment binding by root systems	–
Storm mitigation (non-water-related storms only)	Windbreak and buffering of windstorms and sandstorms	–	–	–
Cultural services				
Recreation-related services	Kayaking, birdwatching, ecotourism	Diving, snorkelling, glass-bottom boat tours	Snorkelling, paddle boarding	Whale watching, sport fishing, sailing
Education, scientific and research services	Mangrove ecology research and education	Coral reef monitoring and marine research	Seagrass ecology and blue carbon research	Oceanographic and marine biology research
Spiritual, artistic and symbolic services	Sacred mangrove forests, cultural heritage sites	Cultural significance of reefs for island communities	–	Spiritual significance of the open ocean

DRAFT

¶3 *Table 1a: Illustrative ecosystem services by marine ecosystem type, following SEEA EA Table 6.3 categories. A dash (–) indicates the service is not typically supplied by that ecosystem type.*

¶4 Abiotic flows from the marine environment (seawater abstraction for desalination and cooling, extraction of seabed minerals and aggregates, and capture of offshore wind, wave, and tidal energy) are recorded separately as contributions from the environment following the SEEA EA framing in Table 6.1[11]. These abiotic flows are distinct from ecosystem services: they arise through abstraction and extraction of resources from geophysical or geological sources rather than being un-

derpinned by ecological characteristics and processes. Compilers are encouraged to record abiotic flows alongside ecosystem services to enable joint analysis of environmental trends, but they should not be classified within the three ecosystem service categories.

Expanded reference: SEEA EA ecosystem services and ocean relevance

¶1 Table 1b provides an expanded reference mapping the ecosystem services from SEEA EA Table 6.3 to their relevance for ocean and coastal accounting. This table is intended to assist compilers in identifying which services from the reference list are most pertinent to their marine accounting area and in selecting appropriate measurement priorities[12].

¶2 **Table 1b: SEEA EA ecosystem services and their ocean relevance**

Ecosystem Service	Relevance to Ocean Accounts
Provisioning services	
Biomass provisioning services (crop provisioning, wood provisioning, wild animals and plants)	Includes timber from mangroves (wood provisioning) and non-fish harvesting in intertidal and coastal areas (wild animals, plants and other biomass provisioning). Crop provisioning is less directly relevant but may apply to cultivated seaweed and coastal salt production.
Wild fish and other natural aquatic biomass provisioning services	Central to ocean accounting. Covers capture fisheries, marine harvesting of shellfish and other aquatic organisms, and all wild-harvest marine biomass in uncultivated production contexts.
Aquaculture provisioning services	Ecosystem contributions to the growth of fish, shellfish, and seaweed in marine and coastal aquaculture facilities. The ecosystem provides water quality maintenance, nutrient cycling, and waste assimilation services that support cultivated production.
Genetic material services	Genetic materials sourced from coastal and marine ecosystems, including bioactive compounds from mangroves, corals, sponges, and deep-sea organisms used in pharmaceutical and biotechnology research.
Water supply	The combined ecosystem contributions of water flow regulation, water purification, and other services to the supply of water of appropriate quality. In coastal contexts, this relates to purification functions of mangroves, tidal flats, estuaries, and coastal vegetation that support freshwater quality in adjacent areas.
Regulating and maintenance services	
Global climate regulation services	Carbon sequestration and storage by phytoplankton in the open ocean, and by mangroves, seagrasses, and salt marshes in coastal zones (blue carbon). The ocean absorbs approximately 25–30% of anthropogenic CO2 emissions, making this one of the most significant marine regulating services.
Local (micro and meso) climate regulation services	Applicable to coastal ecosystems, especially mangroves and coastal vegetation that provide evaporative cooling and shade in tropical coastal settlements. Urban coastal water bodies (blue space) also contribute to local climate regulation.
Air filtration services	Ocean uptake of atmospheric pollutants, including particulate matter deposition on coastal vegetation. Primarily relevant in coastal areas where mangroves and other vegetation filter airborne pollutants affecting nearby communities.
Soil erosion control services	Coastal erosion control and flood protection provided by mangroves, coral reefs, seagrasses, and other coastal vegetation through root stabilisation and wave energy reduction. Includes protection of shorelines, coastal infrastructure, and adjacent agricultural land.
Water purification services (retention and breakdown of nutrients; retention and breakdown of other pollutants)	Retention and breakdown of organic pollutants, excess nutrients, and other contaminants by coastal wetlands, mangroves, and seagrass beds. These services maintain water quality in coastal and nearshore areas, supporting both marine ecosystem health and human uses such as aquaculture and recreation.

DRAFT

Ecosystem Service	Relevance to Ocean Accounts
Water flow regulation services (baseline flow maintenance; peak flow mitigation)	In the marine context, wave regulation and tidal flow moderation by mangroves, coral reefs, and seagrass meadows. Includes baseline flow maintenance in estuarine and lagoon systems and peak flow mitigation during storm and tidal surge events.
Flood control services (coastal protection)	Tidal surge mitigation and coastal protection by linear seascape elements including coral reefs, sand banks, dunes, and mangrove ecosystems along the shore. One of the most economically significant marine regulating services.
Storm mitigation services	Buffering of windstorms, sandstorms and other storms **other than water-related events** (SEEA EA Table 6.3), for example windbreak functions of mangrove and coastal forest canopy. Wave and tidal surge attenuation is *not* recorded here: it is a coastal protection service under flood control, in the row above. Storm mitigation is rarely the material entry in a marine account, and compilers should confirm it is analytically distinct from coastal protection before populating it.
Nursery population and habitat maintenance services	Coastal and marine ecosystems—including mangroves, seagrass meadows, estuaries, and coral reefs—provide critical nursery habitat for commercially important fish species and support the maintenance of marine biodiversity. These are intermediate services that underpin biomass provisioning and recreation-related services.
Solid waste remediation services	Coastal and marine ecosystem contributions to the transformation of organic or inorganic waste substances through microbial, algal, and biological processes. Includes breakdown of organic matter in coastal sediments and remediation functions of mangrove and wetland ecosystems.
Cultural services	
Recreation-related services	Coastal and marine tourism, recreational fishing, diving, snorkelling, surfing, whale watching, and beach recreation. Coral reefs, beaches, and marine protected areas are among the most significant ecosystem types for recreation-related services globally.
Education, scientific and research services	Marine research, oceanographic monitoring, environmental education at coastal and marine sites. Marine ecosystems support scientific discovery and serve as sites for ecological monitoring and education programmes.
Spiritual, artistic and symbolic services	Sacred marine and coastal sites, cultural heritage associated with the ocean, and the spiritual significance of the sea for coastal and island communities. Includes artistic inspiration derived from marine landscapes and seascapes.
Ecosystem and species appreciation	Whale watching, diving with marine megafauna, marine wildlife viewing, and the well-being that people derive from the existence and preservation of marine species and ecosystems. While not classified as an ecosystem service per se, these flows related to non-use values may be recorded alongside ecosystem services.

¶3 *Table 1b: SEEA EA ecosystem services mapped to ocean accounting relevance, based on the reference list in SEEA EA Table 6.3.*

Provisioning services in marine ecosystems

¶1 Marine provisioning services encompass the ecosystem contributions to the growth of biomass and water supply that can be harvested for human use[13]. Key provisioning services in the ocean domain include:

¶2 **Fish provisioning services** represent the ecosystem contributions to the growth of wild fish and other aquatic organisms that are harvested[14]. This service reflects the role of marine ecosystems in supporting fish populations through provision of habitat, food, and suitable environmental conditions. The SEEA EA notes that "provisioning services are recorded in contexts both of cultivation and of non-cultivation"[15]. For wild-capture fisheries the ecosystem provides the service, whilst for aquaculture the ecosystem contribution is distinguished from cultivated inputs. For detailed

guidance on fisheries stock assessment and the relationship between ecosystem services and fish harvests, see **TG-6.7 Fisheries Accounting: Integrating Stock Assessment**.

¶3 **Aquaculture provisioning services** represent ecosystem contributions to the growth of cultivated aquatic organisms[16]. Marine aquaculture depends on ecosystem services including water quality maintenance, nutrient cycling, and waste assimilation. The distinction between wild-capture and aquaculture is important: for aquaculture, part of the biomass growth results from cultivated inputs (feed, seed stock) whilst the ecosystem provides supporting services. The SEEA EA describes this as distinguishing "the contributions made by cultivated inputs from the contributions made by ecosystem assets"[17]. Detailed treatment of aquaculture accounts is provided in **TG-3.9 Aquaculture Accounts**.

¶4 **Other biomass provisioning services** include contributions to the growth of seaweed, shellfish, and other harvestable marine organisms[18]. Seaweed harvesting, for example, depends on ecosystem services that support algal growth, including nutrient availability and suitable water temperature and light conditions.

¶5 **Water supply services** in the marine context relate primarily to the abstraction of seawater for desalination, cooling, and other industrial uses[19]. Whilst seawater itself is typically treated as an abiotic flow rather than an ecosystem service (see Section 3.2), the quality of seawater (its temperature, salinity, and freedom from pollutants) may be influenced by ecosystem processes.

Regulating and maintenance services in marine ecosystems

¶1 Marine regulating and maintenance services matter for ocean accounting, as they encompass many of the non-market contributions that ecosystems make to human well-being[20]. Key categories include:

¶2 **Global climate regulation services** represent ecosystem contributions to the regulation of the global climate through carbon sequestration and storage[21]. Marine ecosystems contribute substantially to the global carbon cycle: the ocean absorbs approximately 25–30% of anthropogenic CO2 emissions, whilst coastal ecosystems such as mangroves, seagrass meadows, and salt marshes sequester carbon at rates far exceeding terrestrial forests[22]. This 'blue carbon' function is increasingly recognised as an ecosystem service. The SEEA EA states that "global climate regulation services represent a final ecosystem service with the user typically recorded as the global community or, where the focus is on a national ecosystem accounting area, the rest of the world"[23].

¶3 The treatment of global climate regulation services raises questions about national attribution. Following SEEA EA para 6.60, when compiling national accounts the service is recorded as supplied by domestic ecosystems and used by the rest of the world (RoW), with the entry in the use table appearing in the RoW column. Countries may additionally record domestic benefits from climate regulation where quantifiable, but should avoid double counting between global and local climate regulation services.

¶4 **Coastal protection services** are the ecosystem contributions to reducing the impacts of coastal hazards including storms, waves, and erosion[24]. Coral reefs, mangroves, seagrass beds, salt marshes, and coastal dunes all provide natural flood and storm protection. The SEEA EA notes that "ecosystem services encompass services that are both predominantly biotic (e.g. air filtration services provided by forests) and predominantly abiotic (e.g. coastal protection services provided by sand dunes)"[25]. For ocean accounting, coastal protection represents one of the most economically significant regulating services, with global estimates suggesting that coral reefs alone provide flood protection benefits exceeding USD 4 billion annually[26]. Thematic guidance on coral reef ecosystem services is provided in **TG-6.1 Coral Reef Ecosystem Accounting**, on mangroves in **TG-6.2 Mangrove and Coastal Wetland Accounting**, and on seagrass in **TG-6.3 Seagrass Ecosystem Accounting**.

DRAFT

¶5 **Water purification services** represent ecosystem contributions to the removal or breakdown of pollutants and other substances from water [27]. Coastal wetlands, mangroves, and seagrass beds filter nutrients, sediments, and pollutants from water flowing from land to sea, maintaining water quality that benefits both marine ecosystems and human uses such as recreation and aquaculture.

¶6 **Nursery population and habitat services** are the ecosystem contributions to the maintenance of populations of species through provision of critical habitat [28]. Many commercially important fish species depend on coastal ecosystems such as mangroves, seagrass meadows, and estuaries as nursery habitat. The SEEA EA treats nursery services as potentially intermediate services: "the nursery population services supplied by seagrass meadows are an input to the supply of fish biomass provisioning services, which in turn contribute to the benefit of marketed fish" [29]. Treating nursery services as intermediate makes the case for recording both final and intermediate ecosystem services, so that the contributions of coastal ecosystems to commercial fisheries are fully captured.

¶7 **Pollination and seed dispersal services** in marine contexts include the dispersal of marine plant propagules and the maintenance of genetic connectivity among populations [30]. Whilst less prominent than in terrestrial ecosystems, these services contribute to the resilience and productivity of marine ecosystems.

¶8 **Soil and sediment retention services** represent ecosystem contributions to preventing erosion and maintaining sediment stability [31]. In coastal areas, vegetation such as mangroves and seagrasses stabilise sediments, reducing erosion and maintaining the physical integrity of coastal ecosystems.

Cultural services in marine ecosystems

¶1 Marine cultural services reflect the experiential, spiritual, and intellectual contributions of ocean ecosystems to human well-being [32]. Many of these contributions (cultural and spiritual values, non-market recreational benefits, subsistence provisioning) are not mediated through market transactions. In the Ocean Accounts Framework (TG-0.1), these non-market ecosystem contributions correspond to Edge E10 (ecosystem services to society beyond the economy), complementing the market-mediated services captured by Edge E9. These include:

¶2 **Recreation-related services** encompass the ecosystem contributions to recreational activities such as swimming, diving, snorkelling, fishing, and wildlife watching [33]. Coral reefs, beaches, and marine protected areas attract tourists and recreational users, and that use generates economic activity. The SEEA EA notes that "recreation-related services are considered final ecosystem services since they are directly enjoyed by people" [34]. For guidance on marine tourism and recreation accounts, see **TG-6.14 Marine and Coastal Tourism Accounting**.

¶3 **Visual amenity services** represent the contribution of ecosystems to aesthetic enjoyment through scenic views and landscapes [35]. Coastal seascapes and marine environments contribute to the amenity value of coastal properties and destinations.

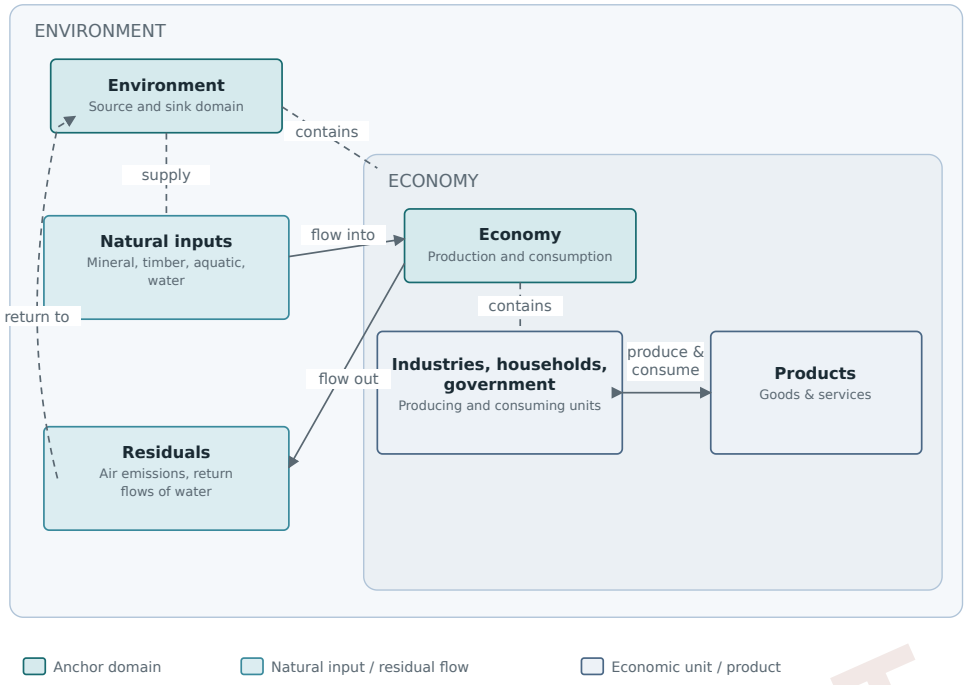
¶4 **Education, scientific, and knowledge services** encompass ecosystem contributions to research, education, and the generation of knowledge [36]. Marine ecosystems are sites of scientific discovery and environmental education, and they are associated with traditional knowledge and cultural significance for coastal communities.

¶5 **Spiritual, artistic, and symbolic services** represent contributions to cultural identity, spiritual practices, and artistic inspiration [37]. For many coastal and island communities, the ocean has profound cultural and spiritual significance. The SEEA EA notes that recording these services may involve "indicators of the physical characteristics associated with the supply of the service" rather than direct measurement of service flows [38].

¶6 Figure 3.2.1 illustrates the structure of flows between the environment and the economy as presented in the 2025 SNA (Figure 35.4). Natural inputs flow from the environment to the economy, whilst residuals flow from the economy back to the environment. Economic units within the econ-

DRAFT

omy produce and consume products. Recording both directions of this flow structure is necessary for ocean accounts that close the environment-economy circuit [39].



DRAFT

Figure 3.2.1 Natural inputs flow from the environment into the nested economy; residuals return the other way.

Source: System of National Accounts 2025, Figure 35.4; environment-economy flow concepts per SEEA Central Framework.

Adapted from: SNA 2025 Figure 35.4 (Flows between the economy and the environment), with GOAP-palette rendering and node-role colouring.

3.2 Natural Resource Inputs

¶1 Natural resource inputs are physical flows from the environment that are moved from their location in the environment as part of economic production processes [40]. The SEEA Central Framework describes natural inputs as encompassing "all physical inputs that are moved from their location in the environment as a part of economic production processes or are directly used in production" [41]. For ocean accounting, key natural resource inputs include:

¶2 **Aquatic resources** extracted through capture fisheries represent the primary natural resource input from marine ecosystems [42]. The SEEA CF recommends measuring extraction as gross catch (the total live weight of fish caught, including discarded catch but excluding pre-catch losses) to capture the full impact on marine resources [43]. The relationship between natural resource inputs (recorded in physical flow accounts) and changes in aquatic resource stocks (recorded in asset accounts as described in **TG-3.1 Asset Accounts**) provides an important consistency check. Specifically, extraction flows recorded in the PSUT should equal extraction entries in the asset account.

¶3 **Water abstraction** includes the removal of seawater and coastal water for use in economic processes [44]. Whilst seawater stocks are not recorded in asset accounts due to their scale, abstraction flows are relevant for understanding industrial use of marine resources, particularly

for desalination and cooling. The SEEA CF notes that "the focus of the SEEA is the inland water system, with provision for the inclusion of sea or ocean water abstracted for production and consumption"[45].

¶4 **Mineral resource extraction** encompasses the removal of sand, gravel, and other seabed materials, as well as extraction of oil, gas, and deep-sea minerals[46]. These extractions are recorded as natural resource inputs in physical flow accounts and correspond to reductions in mineral asset stocks. Detailed guidance on offshore energy accounting is provided in **TG-3.10 Offshore Energy Accounts**.

¶5 **Energy from natural inputs** includes energy captured from marine renewable sources such as tidal, wave, and offshore wind[47]. The SEEA Energy framework describes energy from natural inputs as comprising "flows of energy from the removal and capture of energy from the environment by resident economic units"[48]. These flows are recorded in the physical supply and use tables for energy and represent a growing component of ocean-based economic activity.

Relationship to ecosystem services

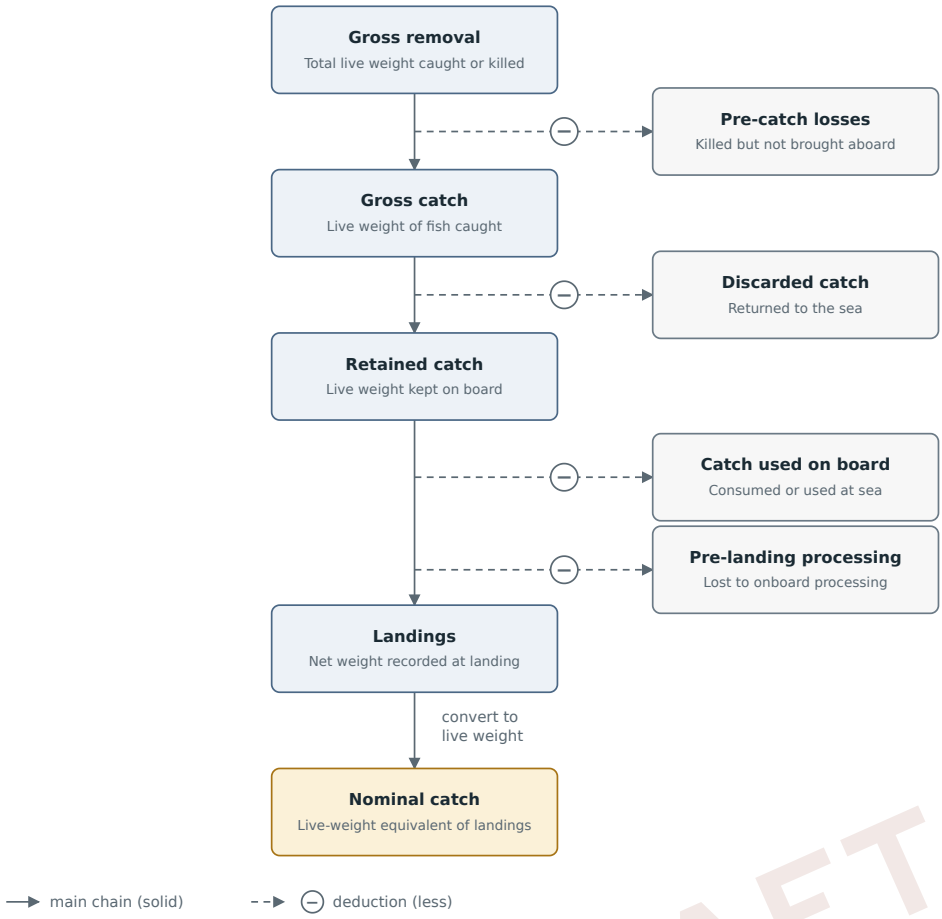
¶1 The relationship between natural resource inputs and ecosystem services requires careful treatment to avoid double counting[49]. The SEEA EA clarifies this relationship:

- ¶2 **Natural inputs** in the SEEA CF include inputs of timber, aquatic resources (e.g. fish), and other biological resources "but only in cases where the production process does not entail cultivation or is unmanaged since cultivated biological resources are produced within the economy"[50].
- ¶3 **Provisioning services** in the SEEA EA are recorded in both cultivation and non-cultivation contexts, reflecting the ecosystem contribution to biomass growth[51].

¶4 For fish, for example, the natural resource input is the harvested catch (a physical flow of biomass from environment to economy), whilst the ecosystem service is the contribution of the marine ecosystem to the growth of that fish population[52]. The two perspectives are complementary: the natural input approach focuses on extraction flows, whilst the ecosystem service approach focuses on the ecosystem's productive contribution. The SEEA EA states that "natural resource residuals represent those flows of natural resources that are extracted or harvested and immediately returned to the environment. Examples include discarded catch in fishing"[53].

¶5 The distinction between gross catch and other catch measures matters for accounting consistency. Figure 3.2.2 illustrates the hierarchical relationships among catch concepts as defined in the SEEA CF, whereby gross removal is progressively refined at each stage to arrive at nominal catch[54].

DRAFT



DRAFT

Figure 3.2.2 Catch concepts reconcile gross removal to FAO nominal catch through successive quantity deductions and a live-weight conversion. Each minus marks a subtracted quantity at that step.

Source: SEEA CF 2012, para. 5.428 and Annex A5.4 (fish catch concepts).

Adapted from: SEEA CF 2012 Annex A5.4.

¶6 Figure 3.2.3 illustrates the dual recording of a single harvest event: as a natural resource input under the SEEA CF and as a complementary provisioning service under the SEEA EA, with each reported in a distinct statistical product and no double-counting between them.

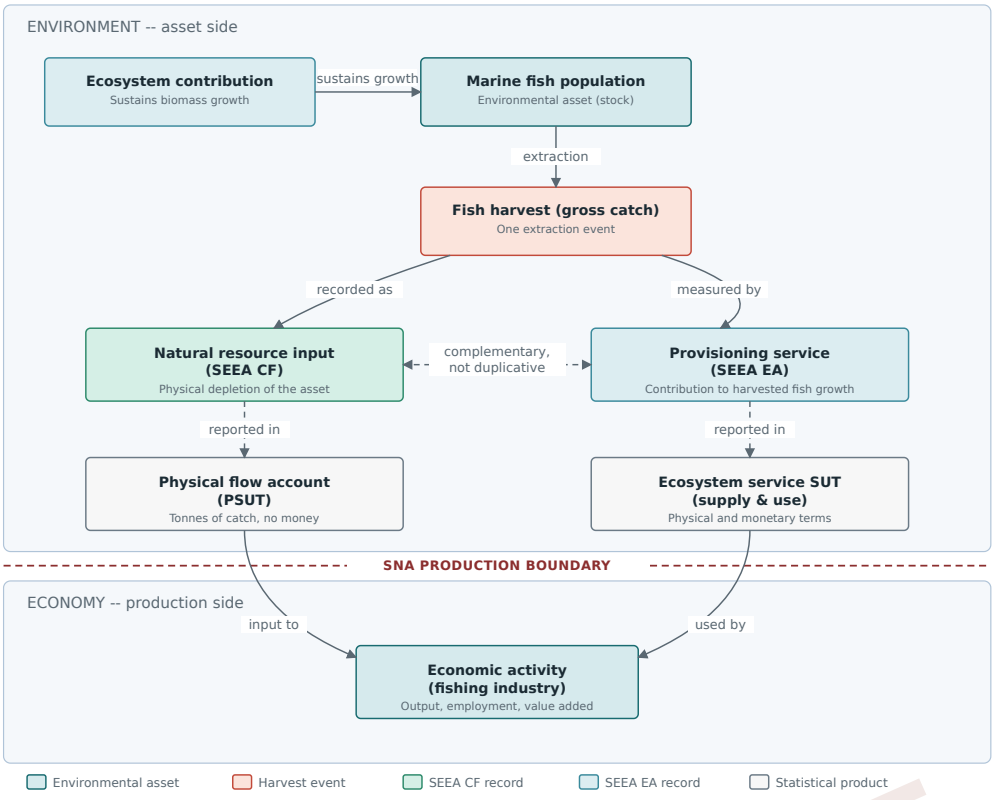


Figure 3.2.3 One harvest event is dual-recorded as a SEEA CF natural-resource input and a SEEA EA provisioning service without double-counting. Records sit in distinct statistical products (PSUT and ecosystem-service SUT), both feeding the fishing industry.

Source: TG-3.2, dual-recording of a transaction in physical and monetary accounts; SEEA CF natural-resource inputs and production boundary; SEEA EA 2024 provisioning ecosystem service flows.

Adapted from: TG-3.2 figure specification (fig-tg-3-2-dual-recording), with GOAP-palette rendering and node colouring by asset / framework / product / economic unit.

DRAFT

Linking extent change to flow categories: the extent-change matrix pattern

¶1 Flows from the environment to the economy depend on both the area and the type of ecosystem present in the accounting area. Where the ecosystem mix changes during the accounting period (for example, mangrove conversion to aquaculture pond, or seagrass loss with retreat to bare seabed), the supply of ecosystem services and natural resource inputs shifts correspondingly. The SEEA EA addresses this through the ecosystem type change matrix (SEEA EA Table 4.2), a square cross-classification of opening extent (rows) against closing extent (columns) by ecosystem type[55]. Each off-diagonal cell records the area converted from one ecosystem type to another during the accounting period, whilst diagonal cells record areas that did not change type[56].

¶2 The matrix is constructed from the same input data as the extent account in **TG-3.1 Asset Accounts** but presented in a way that makes the *direction* of each conversion visible. For ocean accounting, this pattern can be extended as a cross-classifier between opening/closing extent and flow categories: each cell of the matrix can be paired with the change in supply of ecosystem services or natural resource inputs attributable to that conversion. For example, the cell at the intersection of [opening: mangrove] x [closing: aquaculture pond] is associated with reductions in coastal protection, carbon sequestration and nursery services, and a corresponding increase in aquaculture provisioning recorded in the SUT.

¶3 **Structural template — ecosystem type change matrix linked to flow categories (after SEEA EA Table 4.2).** Table 1c presents a blank template. Rows are opening ecosystem types, and columns are closing ecosystem types. The total of each row equals the opening extent for that type, and the total of each column equals the closing extent (the accounting identity from SEEA EA para 4.34)[55]. Where the EAA total area is unchanged between the two points in time, total row sums equal total column sums[56].

¶4 **Table 1c: Ecosystem type change matrix — structural template (after SEEA EA Table 4.2)**

Opening \ Closing	Type 1	Type 2	…	Type *n*	Opening extent (row total)
Type 1	[unchanged area]	[conversion 1->2]	…	[conversion 1->n]	[Σ row]
Type 2	[conversion 2->1]	[unchanged area]	…	[conversion 2->n]	[Σ row]
…	…	…	[unchanged area]	…	[Σ row]
Type *n*	[conversion n->1]	[conversion n->2]	…	[unchanged area]	[Σ row]
Closing extent (column total)	[Σ col]	[Σ col]	…	[Σ col]	[total EAA]

¶5 *Table 1c: Structural template of the ecosystem type change matrix; off-diagonal cells record area converted between ecosystem types; diagonal cells record unchanged area. Cells are blank for compiler population. Structure follows SEEA EA paras 4.34–4.35 and Table 4.2.*[55], [56]

¶6 **Worked instance, from the conversions in the Section 3.4 coastal zone.** The extent account there records mangrove losing 4.0 km² to aquaculture conversion and 2.5 km² to storm erosion, and seagrass losing 0.5 km² to conversion and 1.8 km² to erosion, against managed and natural expansion of 3.3 km² and 1.5 km² respectively. Populating the matrix (km², opening rows against closing columns):

DRAFT

Opening \ Closing	Mangrove	Seagrass	Aquaculture pond	Bare seabed / eroded	Opening extent
Mangrove	493.5	–	4.0	2.5	500.0
Seagrass	–	197.7	0.5	1.8	200.0
Aquaculture pond	2.5	1.2	[n/a]	–	3.7
Bare seabed / eroded	0.8	0.3	–	[n/a]	1.1
Closing extent	**496.8**	**199.2**	**4.5**	**4.3**	**704.8**

¶7 *Table 1f: Ecosystem type change matrix, worked (hypothetical coastal zone, 2025, km²)*

¶8 Read the rows and columns against the extent account and the two agree: mangrove closing extent 493.5 unchanged + 2.5 gained from restored pond area + 0.8 gained by natural expansion = 496.8, which is the closing figure in Table 5 of **TG-3.1**. The matrix adds what the extent account cannot show — that the 6.5 km² of mangrove reduction went to two different places, 4.0 to aquaculture and 2.5 to bare seabed, and that these have different service consequences and different reversibility.

¶9 Paired with the flow change:

Conversion cell	Area (km²)	Service flows lost	Service flows gained
Mangrove → aquaculture pond	4.0	Coastal protection, carbon sequestration, nursery habitat	Aquaculture provisioning

Conversion cell	Area (km²)	Service flows lost	Service flows gained
Mangrove → bare seabed	2.5	Coastal protection, carbon sequestration, nursery habitat	None
Seagrass → aquaculture pond	0.5	Carbon sequestration, nursery habitat	Aquaculture provisioning
Seagrass → bare seabed	1.8	Carbon sequestration, nursery habitat	None

¶10 *Table 1g: Flow-category change paired to the conversion cells of Table 1f*

¶11 The pairing separates the two kinds of loss a planner should treat differently. Conversion to aquaculture trades one set of services for another and the trade can be appraised. Conversion to bare seabed is loss without compensation, and in this zone it accounts for 4.3 km² of the 8.8 km² reduction — nearly half.

¶12 **Pairing extent-change cells with flow-category change.** For each populated off-diagonal cell in the matrix above, compilers should record (in a parallel table or metadata layer) the associated change in flows attributable to the conversion, classified by SEEA EA service category (provisioning, regulating and maintenance, cultural) and by SEEA CF natural resource input category where relevant. SEEA EA para 4.23 notes that conversions imply "the supply of a different set of ecosystem services" [57]. The extent-change matrix therefore bridges the asset (extent) account and the ecosystem services supply table compiled in Section 3.3 below.

¶13 This pattern supports three analytical uses: (a) decomposing observed changes in ecosystem service supply into an *area effect* (extent change) and an *intensity effect* (per-area service flow change driven by condition), (b) identifying the conversions that are responsible for the largest shifts in total service supply across the accounting area, and (c) attributing changes in flows to managed versus unmanaged conversions for policy interpretation. SEEA EA para 4.31 notes that the change matrix may be extended to classify conversions by reasons for change (e.g., urban expansion, salinisation, afforestation), and the same extension applies when pairing the matrix with flow categories [58].

DRAFT

3.3 Physical Supply and Use Tables: Structure and Compilation Procedure

¶1 Two distinct accounts are compiled under this heading and should not be confused. The **SEEA CF physical supply and use table** (CF Table 3.1) records natural inputs entering the economy, products moving within it, and residuals returning to the environment, in one structure. The **SEEA EA ecosystem services supply and use table** records the contributions of ecosystem assets to economic units. They answer different questions about the same harvest: the CF table records the tonnes of fish removed, the EA table records the ecosystem's contribution to those fish having grown.

¶2 This Circular carries the natural-inputs block of the CF table (Section 3.3.1 below) and the whole of the EA table (from Section 3.3.2). **TG-3.4 Flows from the Economy to the Environment** Section 3.4 carries the residuals block. Together the two circulars hold the two halves of CF Table 3.1.

3.3.1 Natural resource inputs supply and use table

¶1 Section 3.2 named the categories of natural input. This is the table they are recorded in. Supply is by the environment, disaggregated by the asset the input is drawn from; use is by the extracting industry. Because natural inputs come from the environment rather than from a producing industry, the supply side has a single origin column, and the analytical content sits in the use side.

¶2 **Table 1d: Natural resource inputs supply and use table — structural template (after SEEA CF Table 3.1)**

Natural input	Unit	Supply from the environment	Fishing (ISIC 03)	Aquaculture (ISIC 03)	Offshore extraction (ISIC 06)	Water supply (ISIC 36)	Energy (ISIC 35)	Oth industries
Biological resources								
Wild aquatic resources (gross catch)	t	[q]	[q]	–	–	–	–	[q]
Other wild biomass (seaweed, shellfish)	t	[q]	[q]	–	–	–	–	[q]
Mineral and energy resources								
Offshore oil and gas	t or m³	[q]	–	–	[q]	–	–	–
Marine aggregates and seabed minerals	t	[q]	–	–	[q]	–	–	[q]
Water resources								
Seawater abstracted	m³	[q]	–	[q]	[q]	[q]	[q]	[q]
Energy from natural inputs								
Offshore wind, wave and tidal energy captured	TJ	[q]	–	–	–	–	[q]	–

¶3 *Table 1d: Structural template of the natural resource inputs supply and use table. One row per input, in the physical unit appropriate to it — these are not additive across rows. Supply from the environment must equal total use for every row.*

¶4 **The consistency check this table exists to make possible.** For every input that is also an asset, the quantity recorded here must equal the extraction entry in the corresponding asset account in **TG-3.1**. Gross catch in the wild aquatic resources row equals the "Gross catch/harvest" reduction in TG-3.1 Table 1; offshore extraction equals the "Extraction" reduction in the mineral column of TG-3.1 Table 1a. A discrepancy is not a rounding matter — it means either the flow or the stock account has missed a removal, and the SEEA CF treats reconciling the two as a primary quality control.

¶5 Using the worked coastal zone of Section 3.4 and the fish stock account in **TG-3.1** Section 3.7:

Natural input	Unit	Supply from the environment	Fishing	Total use	Cross-check against TG-3.1
Wild aquatic resources (gross catch)	t	7,200	7,200	7,200	Equals gross catch in TG-3.1 Table 7 ✓

¶6 *Table 1e: Natural resource inputs, worked fragment (hypothetical coastal zone, 2025)*

¶7 Seawater abstraction is a natural input but seawater is not an asset, because the SEEA CF excludes it from the asset boundary on grounds of scale (Section 3.2). Abstraction is therefore recorded as a flow with no corresponding stock reduction, and no cross-check applies to that row.

3.3.2 Ecosystem services supply and use tables

¶1 Physical supply and use tables (PSUTs) provide the accounting structure for recording flows from the environment to the economy in physical terms [59]. The SEEA Central Framework describes the PSUT as organising information on "the extraction or capture of inputs from the environment, the flows of products within the economy, and the flows of residuals to the environment" [60].

Structure of PSUTs

¶1 The general structure of a PSUT for ecosystem services follows the supply and use framework of national accounts, extended to incorporate ecosystem assets as suppliers [61]:

DRAFT

¶2 **Supply table** — records the supply of ecosystem services by ecosystem type and the supply of products by economic units. For ecosystem services, supply is attributed to the ecosystem assets that generate the services.

¶3 **Use table** — records the use of ecosystem services by economic units (industries, government, households) and the use of products as intermediate consumption and final demand. Users of ecosystem services include the economic units that directly benefit from or incorporate the services into their production or consumption activities.

¶4 The SEEA EA describes the ecosystem services supply and use account structure as having multiple "quadrants" that capture[62]:

- ¶5 Supply of ecosystem services by ecosystem type (ecosystem assets as suppliers)
- ¶6 Use of ecosystem services by economic units (businesses, governments, households)
- ¶7 Supply of products by industries (standard SNA scope)
- ¶8 Use of products by economic units (standard SNA scope)

¶9 Table 2 presents a simplified structure of an ecosystem services supply and use table.

	Ecosystem Types	Industries	Households	Rest of World	Total
SUPPLY					
Ecosystem services	Supply by ET	-	-	-	Total supply
Products	-	Supply by industry	-	Imports	Total supply
USE					
Ecosystem services	-	Use by industry	Use by HH	Exports	Total use
Products	-	Intermediate consumption	Final consumption	Exports	Total use

¶10 *Table 2: Simplified structure of ecosystem services supply and use table (adapted from SEEA EA Figure 7.1)*[63]

DRAFT

Ecosystem services supply-use table: worked template

¶1 Table 2a provides a detailed supply-use table template that compilers can adapt for their ocean accounting area. The supply table records ecosystem service quantities by marine ecosystem type, and the use table records which economic units benefit from each service. Total supply must equal total use for each service (the accounting identity).

¶2 **Table 2a: Ecosystem services physical supply-use table template**

¶3 **SUPPLY TABLE** (Physical units by service type)

Service	Coral Reef	Mangrove	Seagrass	Pelagic	Other Marine	Total Supply
Provisioning						
Fish biomass (tonnes)						
Aquaculture support (tonnes)						
Regulating and maintenance						
Carbon sequestration (tC/yr)						
Coastal protection (km)						
Water filtration (m^3)						
Cultural						

Service	Coral Reef	Mangrove	Seagrass	Pelagic	Other Marine	Total Supply
Recreation (visitor-days)						

¶4 **USE TABLE** (Same physical units)

Service	Fishing	Aquaculture	Tourism	Coastal Properties	Households	RoW	Total Use
Fish biomass (tonnes)							
Aquaculture support (tonnes)							
Carbon sequestration (tC/yr)							
Coastal protection (km)							
Water filtration (m^3)							
Recreation (visitor-days)							

¶5 *Table 2a: Ecosystem services physical supply-use table template for ocean accounts (adapted from SEEA EA Table 7.1)* [64]

¶6 The supply-use accounting identity (Total Supply = Total Use for each service) provides a built-in quality check. Compilers should begin with provisioning services where data are most readily available, then progressively extend to regulating and cultural services as methods and data improve.

Compilation procedure

¶1 The following step-by-step procedure guides the compilation of ecosystem services supply and use tables for ocean accounts:

¶2 **Step 1: Define the accounting area and period.** Specify the spatial extent (e.g., EEZ, coastal zone, sub-national region) and the accounting period (typically one year). Identify the marine and coastal ecosystem types present in the area, drawing on the ecosystem extent account (see **TG-3.1 Asset Accounts**).

¶3 **Step 2: Select ecosystem services to be measured.** Based on Tables 1a and 1b, identify which ecosystem services are relevant to the accounting area. Prioritise services with data availability, policy relevance, and economic significance. Begin with provisioning services (fish harvest, aquaculture), then expand to regulating services (coastal protection, carbon sequestration) and cultural services (recreation).

¶4 **Step 3: Measure supply by ecosystem type.** For each selected ecosystem service, estimate the physical quantity supplied by each ecosystem type during the accounting period. Data sources may include:

- ¶5 Fish provisioning: fisheries statistics (gross catch allocated to fishing grounds by ecosystem type)
- ¶6 Carbon sequestration: biophysical models applied to ecosystem extent and condition data (see **TG-6.2 Mangrove and Coastal Wetland Accounting**)
- ¶7 Coastal protection: spatial analysis of coastal properties protected by different ecosystem types (see **TG-4.1 Remote Sensing and Geospatial Data**)
- ¶8 Recreation: visitor surveys and site counts allocated to ecosystem types

¶9 Record supply quantities in the supply table. Ensure that units are consistent across ecosystem types for each service.

¶10 **Step 4: Identify users of ecosystem services.** For each ecosystem service, identify the economic units that use the service. Users are the direct counterparties in the interaction with the ecosystem:

DRAFT

- ¶11 Fish provisioning: fishing industry (by ISIC division)
- ¶12 Aquaculture provisioning: aquaculture industry
- ¶13 Coastal protection: coastal property owners, local governments, households
- ¶14 Carbon sequestration: rest of the world (following SEEA EA para 6.60)
- ¶15 Recreation: households, tourism industry

¶16 **Step 5: Estimate use by economic unit.** Quantify the use of each ecosystem service by each user. Where direct measurement is not feasible, apply allocation methods:

- ¶17 Provisioning services: use equals the quantity harvested by each industry (from production statistics)
- ¶18 Coastal protection: allocate protected coastline to users based on property value, population, or area protected
- ¶19 Recreation: allocate visitor-days to households and tourism businesses based on survey data

¶20 Record use quantities in the use table.

¶21 **Step 6: Check accounting identity.** For each ecosystem service, verify that Total Supply = Total Use. If the identity does not hold, review data sources and allocation assumptions. Common sources of discrepancy include:

- ¶22 Unidentified users (e.g., recreation by non-residents not captured in surveys)
- ¶23 Incomplete spatial coverage (e.g., fishing grounds extending beyond the mapped ecosystem extent)
- ¶24 Measurement errors in supply or use estimates

¶25 **Step 7: Document methods and assumptions.** Record all data sources, allocation methods, and assumptions in metadata accompanying the accounts. Note areas where measurement quality is limited and where future improvements are planned. This documentation is essential for quality assurance and for interpreting the accounts in policy applications.

¶26 **Step 8: Compile monetary accounts (if applicable).** Apply valuation methods (see Section 3.5) to the physical supply and use tables to derive monetary accounts. The monetary valuation should be compiled separately from physical accounts to maintain transparency and let users assess the valuation assumptions.

DRAFT

Compiling the supply table

¶1 The ecosystem services supply table records the physical quantities of ecosystem services supplied by different ecosystem types [65]. For each ecosystem service, the entry reflects the total flow over the accounting period (typically one year), measured in appropriate physical units.

¶2 Key considerations for compiling the supply table include:

¶3 **Attribution to ecosystem types** — Provisioning services are relatively straightforward to attribute to specific ecosystem types (e.g., fish provisioning to marine shelf ecosystems). However, "for some services, particularly regulating services such as carbon sequestration, the same service will be supplied by more than one ecosystem type" [66]. The SEEA EA recommends that compilers "create a table showing which ecosystem services are likely to be supplied from different ecosystem types for their country or target ecosystem accounting area" [67].

¶4 **Spatial allocation** — For ecosystem services whose supply depends on interactions among multiple ecosystem types, "some allocation of ecosystem service flow between ecosystem types will be required" [68]. This is particularly relevant for coastal protection and climate regulation services that may be supplied by a mosaic of ecosystem types.

¶5 **Measurement units** — Physical units vary by service type: tonnes for biomass provisioning, tonnes of carbon for climate regulation, hectares protected for coastal protection, visitor-days for

recreation[69]. The SEEA EA provides guidance on possible metrics for each service type.

Compiling the use table

¶1 The ecosystem services use table records the use of ecosystem services by different economic units[70]. The SEEA EA notes that "the focus of the use table is on the link between ecosystem services and different types of users, while the supply table focuses on the supply from ecosystem types"[71].

¶2 Key considerations for compiling the use table include:

¶3 **Identifying users** — Users are the economic units that directly interact with or benefit from the ecosystem service. For provisioning services, users are typically the industries that harvest or extract the resource. For regulating services, users may be more dispersed—coastal protection benefits property owners, local governments, and the broader community. The SEEA EA distinguishes between "users" (direct counterparties in the interaction with the ecosystem) and "beneficiaries" (the broader set of economic units that ultimately receive benefits)[72].

¶4 **Location of users** — "While the supply of ecosystem services can be directly linked to a spatial area (e.g. to an ecosystem asset), there is no requirement that the location of the user is the same as the location of the area from which the ecosystem service is supplied"[73]. This is especially relevant for regulating services and cultural services, where benefits may accrue to distant populations.

¶5 **Supply equals use** — In accounting terms, total supply must equal total use for each ecosystem service[74]. This accounting identity ensures consistency and completeness and provides a basis for quality assurance of ecosystem service accounts.

> *Practical guidance: Informal and unregistered beneficiaries of regulating services*
> *Coastal protection and water purification services disproportionately benefit low-income coastal communities, subsistence households, and informal settlements that are systematically undercounted in national household surveys and industry registers. Omitting these beneficiaries from the use table breaks the supply = use identity, and assigning them to a residual "households" cell without supporting data produces unreliable indicators. Compilers should:*
>
> 1. ¶6 *Use* ***population census and spatial settlement data*** *(including UN-Habitat informal settlement layers and equivalent national datasets) to estimate the* ***total beneficiary population*** *within the protective ecosystem's zone of influence, irrespective of survey-frame coverage.*[75]
> 2. ¶7 *Where household-survey data are unavailable, apply a* ***coastal proximity proxy****: "all resident households within X km of the protective shoreline" (X chosen based on national hazard-zone definitions or the relevant return-period inundation extent) and allocate the relevant share of service use to households on this basis.*
> 3. ¶8 ***Document residual unallocated use*** *explicitly, including the estimation method used for informal beneficiaries and the assumed coastal proximity radius, in compilation metadata. See TG-4.2 Survey Methods for survey design options.*

> *Boundary call-out: Wild seed extraction vs nursery habitat services*
> *Where an entry attributes wild juveniles to aquaculture — a "wild seed extraction" row — it represents* ***extraction of wild juveniles*** *from coastal ecosystems for transfer to aquaculture pens. Following SEEA EA paras. 6.11–6.17, this is recorded as a flow that simultaneously appears (a) here in the ecosystem-service use table as a service flow to aquaculture, and (b) in the* ***aquatic resource asset account*** *as an extraction reducing the wild stock — consistent with the asset-account treatment in TG-3.1 Asset Accounts and TG-3.9 Aquaculture Accounts. The conceptually distinct* ***nursery habitat service*** *(ecosystem support for wild juvenile recruitment that subse-*

DRAFT

> *quently contributes to commercial fish biomass) is recorded separately as an intermediate regulating service and is not aggregated into the 700-tonne entry. Confusing the two would double-count the ecosystem contribution.*

Delineating the service providing and benefiting areas: coastal protection

¶1 SEEA EA §7.66 defines the **service providing area (SPA)** and the **service benefiting area (SBA)** as the spatial boundaries of supply and use for a given service. Coastal protection — a sub-service of flood control services in the Table 6.3 reference list — is the clearest marine case in which the two areas are distinct rather than coincident, and is set out here as the pattern to follow for other spatially separated services.

- ¶2 **Service providing area (SPA):** the spatial extent of coastal ecosystems supplying wave attenuation and surge dissipation in the reference period — typically coral reefs at relevant depth bands, mangrove forests, saltmarsh, seagrass beds and natural coastal dunes. Extent is taken from the ecosystem extent account (**TG-3.1 Asset Accounts** Section 3.5.1).
- ¶3 **Service benefiting area (SBA):** the populated and built-up land behind the SPA whose exposure to storm surge, wave overtopping and erosion is materially reduced by the SPA. Delineated using elevation, surge modelling and population or asset rasters.
- ¶4 **Service flow (physical):** the with/without-ecosystem differential in expected flood depth, area inundated, population exposed or assets exposed, attributed to the SPA over a defined reference period.
- ¶5 **Service flow (monetary):** the with/without-ecosystem differential in expected annual damages, valued using avoided-damage and expected-expenditure methods (Section 3.5).

¶6 The counterfactual is what makes this service measurable: the model is run with current ecosystem extent and again with the ecosystems removed or degraded, and the difference is the service flow attributed to the SPA. Data sources and models for that counterfactual are in **TG-4.1 Remote Sensing and Geospatial Data**. The dependency and vulnerability indicators derived from these entries are in **TG-2.3 Social and Livelihood Dependencies** Section 3.4.

DRAFT

Physical units and measurement

¶1 The SEEA EA recommends that ecosystem services be measured in physical terms before monetary valuation[76]. Physical measurement provides the foundation for understanding the actual flows between ecosystems and the economy, and supports the application of different valuation approaches.

¶2 For marine ecosystem services, relevant physical units include[77]. Table 3.3.1 below summarises the recommended units.

Service	Physical units
Fish provisioning	Tonnes of biomass harvested (gross catch).
Global climate regulation	Tonnes of carbon sequestered (annual sequestration flow).
Coastal protection	Hectares of coastline protected, or metres of coastline; alternative metrics include population or assets protected.
Water purification	Volumes of water filtered (cubic metres), or pollutant loads removed (tonnes).
Recreation	Visitor-days, or area available for recreation (hectares).

¶3 For guidance on spatial data sources and methods for measuring ecosystem service supply, see **TG-4.1 Remote Sensing and Geospatial Data** and **TG-4.2 Survey Methods for Ocean Economic Activity**.

Worked example: supply-use entries under a spatial conversion scenario

¶1 Where a plan or appraisal converts one ecosystem type to another, the change has to be reflected consistently in the extent account and in the services supply-use table. This example traces those entries for a conversion scenario of the kind evaluated in **TG-1.2 OA and Marine Spatial Planning** Section 3.5.

¶2 **Scenario:** a marine spatial plan converts 500 ha of mangrove to an aquaculture zone.

¶3 **Step 1: Extent account adjustment**

¶4 In the ecosystem extent account for the mangrove ecosystem type:

- ¶5 Opening stock: [baseline mangrove area, ha]
- ¶6 Reduction — conversion to aquaculture: −500 ha
- ¶7 Closing stock: [opening stock minus 500 ha]

¶8 In the extent account for the aquaculture zone land use category:

- ¶9 Opening stock: [baseline aquaculture area, ha]
- ¶10 Addition — conversion from mangrove: +500 ha
- ¶11 Closing stock: [opening stock plus 500 ha]

¶12 **Step 2: Services supply-use table adjustments**

¶13 The supply-use table for ecosystem services records, by ecosystem type and service, the physical quantity supplied (by ecosystem) and used (by economic sector or final beneficiary). The following rows change:

Service	Row/column affected	Direction	Basis for estimate
Coastal protection	Mangrove supply row — coastal protection service	Decrease	Proportional to extent lost: if 500 ha represents X% of total mangrove area, coastal protection supply decreases by approximately X% of baseline flow
Carbon sequestration	Mangrove supply row — carbon sequestration service	Decrease	Mangrove carbon sequestration rate (tCO2/ha/yr) × 500 ha lost
Nursery habitat	Mangrove supply row — nursery habitat service	Decrease	Proportional to extent lost, scaled by species-specific habitat dependency ratios
Aquaculture production	Aquaculture zone supply row — provisioning service	Increase	Projected yield (tonnes/ha/yr) × 500 ha × aquaculture production rate

¶14 **Step 3: Cross-account consistency check**

¶15 Verify that the service flow changes in Step 2 are reflected in:

- ¶16 The economic account: reduced fish provisioning from mangrove-dependent fisheries (nursery habitat loss); increased aquaculture output
- ¶17 The condition account: if extent loss reduces structural state variables (e.g., shoreline habitat complexity), update the condition index accordingly following **TG-2.1** Section 3.4.1 and TG-3.1 Section 3.5.2

¶18 The full supply-use table structure and column definitions are given in Section 3.3 above; the extent-account entries are compiled following **TG-3.1 Asset Accounts** Section 3.5.1.

¶19 Scenario projections of this kind are estimates, not account entries. They should be labelled as projections and reconciled against the compiled accounts once the conversion has occurred.

3.4 Worked Example: Coastal Zone Ecosystem Services Account

DRAFT

¶1 This section presents a worked example of ecosystem services supply and use tables for a hypothetical coastal zone, using synthetic data to illustrate the compilation procedure described in Section 3.3. The example demonstrates how to organise data, apply allocation methods, and verify accounting identities.

Accounting context

¶1 The hypothetical accounting area is a 50km coastal zone with four ecosystem types: mangroves (500 ha), coral reefs (1,200 ha), seagrass meadows (800 ha), and open marine shelf (5,000 ha). The accounting period is one year (2025). Three ecosystem services are measured: fish provisioning (tonnes harvested), carbon sequestration (tonnes C per year), and coastal protection (km of coastline protected). Three user categories are identified: fishing industry, coastal properties, and rest of world (RoW).

Step 1: Supply table compilation

¶1 **Fish provisioning (tonnes)**: Gross catch statistics indicate 2,400 tonnes of fish harvested from the zone. Spatial analysis of fishing grounds and ecosystem productivity estimates allocate catch as follows:

- ¶2 Mangroves: 400 tonnes (nursery habitat for inshore species)
- ¶3 Coral reefs: 600 tonnes (reef-associated species)
- ¶4 Seagrass meadows: 300 tonnes (seagrass-associated species)
- ¶5 Open marine shelf: 1,100 tonnes (pelagic and demersal species)

¶6 **Carbon sequestration (tonnes C/yr)**: Biophysical models estimate annual carbon sequestration rates per hectare for each ecosystem type, then scale by extent:

- ¶7 Mangroves: 500 ha × 2.5 tC/ha/yr = 1,250 tC/yr
- ¶8 Coral reefs: limited sequestration (calcification offsets), estimated at 50 tC/yr
- ¶9 Seagrass meadows: 800 ha × 1.5 tC/ha/yr = 1,200 tC/yr
- ¶10 Open marine shelf: phytoplankton sequestration estimated at 500 tC/yr for the shelf area

¶11 **Coastal protection (km)**: Spatial analysis identifies 30 km of coastline within the zone. Coastal protection service is attributed to ecosystems based on their position and protective capacity:

- ¶12 Mangroves: 8 km (direct frontal protection)
- ¶13 Coral reefs: 12 km (offshore wave attenuation)
- ¶14 Seagrass meadows: 5 km (supplementary wave dampening in shallow areas)
- ¶15 Open marine shelf: 0 km (no direct coastal protection function)
- ¶16 Overlap: 5 km protected by multiple ecosystem types (mangroves + coral reefs). This is allocated 3 km to coral reefs (primary protection) and 2 km to mangroves (secondary protection) to avoid double counting.

¶17 Adjusted total: Mangroves 10 km, Coral reefs 15 km, Seagrass 5 km.

¶18 **Supply table (Table 3a)**

Service	Mangroves	Coral Reefs	Seagrass	Open Marine	Total Supply
Fish biomass (tonnes)	400	600	300	1,100	2,400
Carbon sequestration (tC/yr)	1,250	50	1,200	500	3,000
Coastal protection (km)	10	15	5	0	30

¶19 *Table 3a: Supply of ecosystem services by marine ecosystem type (hypothetical coastal zone, 2025)*

Step 2: Use table compilation

DRAFT

¶1 **Fish provisioning (tonnes)**: All 2,400 tonnes are used by the fishing industry. Production statistics indicate industrial fishing operations harvest 1,800 tonnes and small-scale fishing operations harvest 600 tonnes.

¶2 **Carbon sequestration (tC/yr)**: Following SEEA EA para 6.60, global climate regulation services are attributed to the rest of world (RoW). All 3,000 tC/yr are recorded as used by RoW.

¶3 **Coastal protection (km)**: The 30 km of protected coastline benefits coastal properties (residential, commercial, and government infrastructure). Survey data indicate that 25 km protects private properties and 5 km protects public infrastructure (recorded under government/households).

¶4 **Use table (Table 3b)**

Service	Fishing Industry	Coastal Properties	Households/Government	RoW	Total Use
Fish biomass (tonnes)	2,400	0	0	0	2,400
Carbon sequestration (tC/yr)	0	0	0	3,000	3,000
Coastal protection (km)	0	25	5	0	30

¶5 *Table 3b: Use of ecosystem services by economic unit (hypothetical coastal zone, 2025)*

Step 3: Accounting identity verification

¶1 For each service, Total Supply = Total Use:

- ¶2 Fish biomass: 2,400 = 2,400 ✓
- ¶3 Carbon sequestration: 3,000 = 3,000 ✓
- ¶4 Coastal protection: 30 = 30 ✓

¶5 The accounting identity holds for all services, confirming internal consistency.

Interpretation for policy analysis

¶1 These accounts provide the foundation for deriving indicators that support policy questions:

¶2 **Ecosystem dependency**: The fishing industry depends entirely on marine ecosystem services for its inputs (2,400 tonnes of fish). This dependency can be expressed as a ratio of ecosystem service input to industry output value. A high ratio signals exposure to ecosystem degradation, not vulnerability. Whether a decline in the service would cause loss also depends on how sensitive the industry's output is to that decline and on its capacity to substitute for the service or adapt; the accounts do not generally record substitutability or adaptive capacity, which need separate analysis [78] (for the community-level equivalent, see the livelihood vulnerability index in **TG-2.3 Social and Livelihood Dependencies**).

¶3 **Coastal protection value**: The 30 km of protected coastline can be valued using replacement cost or avoided damage cost methods (see Section 3.5). The replacement cost of equivalent engineered coastal protection is estimated at USD 5 million per km of coastline, yielding a total replacement cost of USD 150 million for 30 km. Annualising this over a 20-year infrastructure lifespan at a 5% discount rate yields an annual equivalent service value of approximately USD 12 million per year (USD 0.4 million per km per year). Alternatively, avoided damage costs may be estimated from storm surge modelling.

¶4 **Carbon sequestration contribution**: The 3,000 tC/yr sequestered by coastal ecosystems can be valued at the social cost of carbon (e.g., USD 50 per tonne CO2-equivalent, or approximately USD 183 per tonne C), yielding an annual service value of approximately USD 550,000. This service flows to the rest of the world, representing a contribution to global climate regulation.

¶5 **Cross-stack linkages**: These flow accounts connect downward to **TG-4.1 Remote Sensing and Geospatial Data** (ecosystem extent mapping), sideways to **TG-3.1 Asset Accounts** (ecosystem

DRAFT

condition and capacity), and upward to **TG-2.4 Ecosystem Goods and Services** (indicator derivation). They inform sustainable yield calculations for fisheries (**TG-6.7 Fisheries Accounting: Integrating Stock Assessment**), blue carbon policy (**TG-6.2 Mangrove and Coastal Wetland Accounting**), and coastal zone management (**TG-1.2 Marine Spatial Planning**).

3.5 Monetary Valuation of Flows

¶1 Monetary valuation of ecosystem service flows enables comparison across service types, aggregation with other economic flows, and integration into economic decision-making [79]. Because most ecosystem services are not traded in markets, most entries require estimation.

¶2 **Where the method is specified.** The value concepts, the SEEA EA five-level preference order, the methods available at each level, the methods that are not admissible in accounts, and a worked application across four marine services are all in **TG-2.4 Environmental (including Ecosystem) Goods and Services** Section 3.10, which is normative for the choice of method. **TG-1.9 Safe Usage of Monetary Valuation** covers whether and when to value at all, and how the resulting figures should be communicated. Asset-level valuation — the NPV of service flows, the discount rate and the horizon — is **TG-3.1 Asset Accounts** Section 3.3. None of that is restated here.

¶3 What this Circular specifies is how a monetary value attaches to a **flow entry** in the supply and use table, which is a different question from which method produced the number.

Attaching values to supply and use entries

¶1 **Value the same physical flow that the physical table records.** Each monetary entry corresponds cell-for-cell to a physical entry compiled under Section 3.3. Where the physical table splits a service across ecosystem types, or across final and intermediate uses, the monetary table carries the same split. A monetary total that cannot be decomposed back onto the physical rows is not a supply and use entry.

¶2 **Exchange values, not welfare values.** The accounts record the values at which services are or could be exchanged, excluding consumer surplus [80]. This is what makes the entries additive with the rest of the national accounts, and it is the single most common reason a published valuation study cannot be used as an account entry without adjustment.

¶3 **The identity applies to the monetary tables too.** Total monetary supply equals total monetary use for each service, at the same unit prices. Where supply and use are valued differently — for instance a service supplied domestically and used by the rest of the world — the price basis for each side must be documented.

¶4 **Value only what the physical account can support.** Where a service has been recorded in physical terms but the compiler has no admissible method for valuing it, the monetary cell is left empty and flagged, not filled with a benefit-transfer figure carried over from another country. Physical accounts should always be compiled as the primary output.

¶5 The SEEA EA describes monetary valuation principles as "internationally recognised statistical principles and recommendations" (SEEA EA Preface, para 8) rather than a full international statistical standard. Compilers should document the methods, assumptions and uncertainties involved in their valuations.

Valuation of provisioning services

¶1 Provisioning services are generally the most amenable to valuation, as they contribute to marketed goods [81]. The **resource rent** approach is commonly applied, estimating the ecosystem service value as the residual after deducting costs of labour, produced assets, and intermediate inputs from the value of output [82].

¶2 For fish provisioning services, the resource rent is calculated as [83]:

DRAFT

> *Resource rent = Output value - Intermediate consumption - Compensation of employees - Consumption of fixed capital - Return on produced assets*

¶3 This residual represents the return attributable to the natural resource input and the ecosystem's contribution to fish growth. The SEEA EA notes that "exchange values for provisioning services are likely to be estimated based on observed market transactions"[84]. The SEEA Valuation Guidelines elaborate that "the residual value and resource rent methods estimate the value for an ecosystem service by first taking the gross output value of the final marketed good to which the ecosystem service provides an input, and then deducting the cost of all other inputs"[85].

Valuation of regulating and maintenance services

¶1 Regulating and maintenance services present greater valuation challenges, as they typically contribute to non-marketed benefits. Several approaches may be applied[86]:

¶2 **Replacement cost method** estimates the cost of replacing an ecosystem service with an engineered or artificial substitute[87]. For coastal protection, this might involve comparing the protection provided by a coral reef or mangrove with the cost of constructing a sea wall or breakwater. The SEEA Valuation Guidelines note that "mangroves may be planted or restored as a 'green infrastructure' alternative to 'hard' engineered flood defences"[88]. The validity of the replacement cost method depends on three conditions: "the substitute can provide exactly the same function of the good or service substituted for; the substitute is actually the least-cost alternative; and evidence indicates an actual demand for the substitute"[89].

¶3 **Avoided damage cost method** estimates value based on the damages that would occur in the absence of the ecosystem service[90]. For coastal protection, this involves estimating the expected damages from flooding or erosion that are prevented by the ecosystem. The SEEA Valuation Guidelines state that "the validity of the avoided damage cost method depends on conditions including that the damages avoided can be related to a specific service; and that people would be willing to pay an amount to actually avoid the damage"[91].

¶4 **Productivity change method** estimates value based on the contribution of ecosystem services to the productivity of economic activities[92]. This approach can be applied where ecosystem services (such as nursery habitat for fish) enhance the productivity of commercial fisheries.

¶5 For **global climate regulation services**, valuation typically applies the **social cost of carbon** or market prices from carbon trading systems[93]. However, the SEEA EA notes that "global climate regulation services represent a final ecosystem service with the user typically recorded as the global community"[94], raising questions about attribution of values to national accounts. For guidance on carbon accounting and valuation in the marine context, see **TG-6.2 Mangrove and Coastal Wetland Accounting**.

Valuation of cultural services

¶1 Cultural services, particularly recreation, can be valued using **travel cost** and **consumer expenditure** methods[95]. The travel cost method estimates demand for recreation sites based on the costs visitors incur to reach them. The consumer expenditure method uses actual expenditures (travel, accommodation, entry fees) as a proxy for willingness to pay[96].

¶2 The SEEA Valuation Guidelines describe the travel cost method as "based on measuring the costs incurred (and the foregone income) by households or individuals to reach a site and hence receive an ecosystem service from the site, usually in the context of recreation activity"[97]. For marine recreation, this method has been applied to value diving and snorkelling at coral reefs, coastal fishing, and beach visits.

DRAFT

¶3 **Hedonic pricing** may be applied to visual amenity services, estimating the premium on property values attributable to proximity to or views of marine environments[98]. The SEEA Valuation Guidelines note that "applications of hedonic pricing have grown substantially in recent years" for nature views, open spaces, and water quality[99].

The monetary ecosystem services supply and use table

¶1 The methods above value a service. They do not, on their own, produce an account. **SEEA EA (https://seea.un.org/sites/seea.un.org/files/documents/EA/seea_ea_white_cover_final.pdf) Chapter 9** specifies the monetary supply and use account, which takes the physical table compiled in Section 3.3 and restates every cell in currency units at the exchange value of the service. It is the bridge between the physical service flows recorded here and the net present value of the ecosystem asset in **TG-3.1** Section 3.5.3: the asset value is the discounted stream of the flows in this table, and cannot be compiled without it.

¶2 The four rules in *Attaching values to supply and use entries* above govern every cell of this table: cell-for-cell correspondence with the physical entry, exchange values rather than welfare values, the supply-equals-use identity in currency units, and an empty flagged cell wherever no admissible method exists. The table adds one requirement of its own.

¶3 **The unit value is an explicit column, not an implied one.** Total monetary supply for a service equals its physical quantity multiplied by a unit exchange value, and the account records all three. Recording only the product hides which of the two moved. This is the same separation the revaluation entry provides in the asset account, and without it a rise in the value of a service is indistinguishable from a rise in the flow of it.

¶4 **Table 2b: Ecosystem services monetary supply-use table — structural template (after SEEA EA Chapter 9)**

¶5 **MONETARY SUPPLY TABLE** (currency units)

Service	Physical quantity	Unit exchange value	Valuation method and preference level	Coral Reef	Mangrove	Seagrass	Pelagic
Provisioning							
Fish biomass	[t]	[cur/t]	Resource rent (L3)				
Aquaculture support	[t]	[cur/t]	Resource rent (L3)				
Regulating and maintenance							
Carbon sequestration	[tC/yr]	[cur/tC]	[method] (L5)				
Coastal protection	[km]	[cur/km]	Avoided damage cost (L5)				
Water filtration	[m^3]	[cur/m^3]	Replacement cost (L5)				
Cultural							
Recreation	[visitor-days]	[cur/day]	Travel cost (L4)				
Total	–	–	–				

¶6 **MONETARY USE TABLE** (currency units)

DRAFT

Service	Fishing	Aquaculture	Tourism	Coastal proper-ties	Households	Government	I
Fish biomass							
Aquaculture support							
Carbon sequestration							
Coastal protection							
Water filtration							
Recreation							
Total							

¶7 *Table 2b: Structural template of the monetary ecosystem services supply and use table. Rows and columns mirror Table 2a exactly. The preference level in the method column is the level from the hierarchy in Table 3.5.1 and in TG-2.4 Section 3.10, and recording it in the account is what lets a user judge how far a figure sits from an observed price.*

¶8 **Worked example, continuing the coastal zone of Section 3.4.** Applying the unit values derived in that section's interpretation to the physical quantities in Tables 3a and 3b:

Service	Physical quan-tity	Unit exchange value	Method (level)	Mangroves	Coral reefs	Seagrass
Fish biomass (t)	2,400	USD 450/t	Resource rent (L3)	180,000	270,000	135,000
Carbon sequestration (tC/yr)	3,000	USD 183/tC	Social cost of carbon (L5)	228,750	9,150	219,600
Coastal protection (km)	30	USD 400,000/km/yr	Annualised replace-ment cost (L5)	4,000,000	6,000,000	2,000,00
Total supply	–	–	–	**4,408,750**	**6,279,150**	**2,354,60**

DRAFT

¶9 *Table 3d: Monetary supply of ecosystem services by marine ecosystem type (hypothetical coastal zone, 2025, USD/year)*

Service	Fishing industry	Coastal properties	Households/Government	RoW	Total use
Fish biomass	1,080,000	0	0	0	1,080,000
Carbon sequestration	0	0	0	549,000	549,000
Coastal protection	0	10,000,000	2,000,000	0	12,000,00
Total use	**1,080,000**	**10,000,000**	**2,000,000**	**549,000**	**13,629,00**

¶10 *Table 3e: Monetary use of ecosystem services by economic unit (hypothetical coastal zone, 2025, USD/year)*

¶11 Total supply equals total use for each service and in aggregate (USD 13,629,000), the same check as Section 3.4 Step 3 applied in currency units.

¶12 **Reading the monetary table against the physical one.** The two tables rank the ecosystems differently, and that difference is the analytical payload. In physical terms the open marine shelf is the largest single supplier of fish (1,100 of 2,400 tonnes) and mangroves the largest supplier of carbon sequestration. In monetary terms coral reefs are the most valuable ecosystem in the zone

(USD 6.28 million of USD 13.63 million), on the strength of coastal protection alone — a service measured in kilometres, whose unit value is two orders of magnitude above anything else in the table. Carbon sequestration, which dominates the physical regulating-service rows, is 4 per cent of the monetary total.

¶13 Two cautions follow, and both should be carried into any use of these figures. First, the ranking is a ranking of *unit values*, and the three unit values here come from three different levels of the preference hierarchy: the fish rent is close to an observed price, the coastal protection figure is an annualised engineering cost, and the carbon figure is a policy parameter. Aggregating across levels is permitted but the composition should be disclosed. Second, USD 12 million of the USD 13.6 million total rests on a single replacement-cost estimate, so the total is about as reliable as that one number. Present the composition, not only the total.

Integration with ecosystem asset valuation

¶1 The monetary value of ecosystem services provides the basis for valuing ecosystem assets themselves. Under the net present value (NPV) approach, ecosystem asset value equals the discounted stream of expected future ecosystem service flows[100]:

> *Ecosystem asset value = Sum of (Expected future ecosystem service flows / (1 + discount rate)^t)*

¶2 This creates an important link between flow accounts (ecosystem services) and stock accounts (ecosystem assets) as described in **TG-3.1 Asset Accounts**.

¶3 Changes in ecosystem service flows—whether due to changes in ecosystem extent, condition, or external factors—directly affect ecosystem asset values. The concept of **degradation** in SEEA EA captures the loss in asset value attributable to decline in ecosystem condition and associated reduction in ecosystem service supply[101]. The SEEA EA describes degradation as involving "measuring the value of degradation in terms of loss in future value of ecosystem services due to a decline in ecosystem condition"[102]. This linkage between flow and asset accounts ensures consistency in the accounting framework and supports analysis of the sustainability of ecosystem use.

DRAFT

Implementation Considerations

¶1 For minimum institutional capacity, data infrastructure, and human skills requirements for compiling these accounts, see TG-0.8 Implementation Readiness Assessment. For guidance on adapting these methods to sub-national scales, see TG-3.11 Sub-National Ocean Accounts.

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

FOOTNOTES

1. ¶1 SEEA EA, para 1.12. The SEEA EA framework "describes the relationship between the environment and the economy" through ecosystem services.
2. ¶2 SEEA EA, para 1.12
3. ¶3 SEEA CF, para 3.45; SEEA EA, para 6.8
4. ¶4 SEEA EA, para 2.14. "Ecosystem services are the contributions of ecosystems to the benefits that are used in economic and other human activity."
5. ¶5 SEEA EA, para 6.10. "In ecosystem accounting, ecosystem services are recorded as flows between ecosystem assets and economic units."
6. ¶6 SEEA EA, para 6.43-6.45 and Table 6.3
7. ¶7 CICES (Common International Classification of Ecosystem Services). The SEEA EA Technical Recommendations note that "the use of a classification of ecosystem services, such as CICES, FEGS-CS or NESCS is an important as-

pect in compiling estimates of ecosystem services flows." (para 5.67)

8. ¶8 Adapted from SEEA EA Table 6.3
9. ¶9 SEEA EA Technical Recommendations, para 5.22. Compilers are encouraged to create a mapping table showing which ecosystem services are likely to be supplied from different ecosystem types for their accounting area.
0. ¶10 SEEA EA, para 6.51 and Table 6.3. The reference list encompasses three broad categories: provisioning services, regulating and maintenance services, and cultural services.
1. ¶11 SEEA EA, para 6.35 and Table 6.1. The SEEA EA framing of contributions from the environment distinguishes (a) ecosystem services, (b) abiotic flows, and (c) spatial functions. Abiotic flows are "contributions to benefits from the environment that are not underpinned by, or reliant on, ecological characteristics and processes."
2. ¶12 SEEA EA, Table 6.3 and para 6.44-6.54. The reference list of selected ecosystem services provides labels and descriptions for a set of key ecosystem services relevant for ecosystem accounting.
3. ¶13 SEEA EA, para 6.46
4. ¶14 SEEA EA, Table 6.3, row 1
5. ¶15 SEEA EA, para 1.81
6. ¶16 SEEA EA, para 7.31-7.33
7. ¶17 SEEA EA, para 7.33. "The aim in ecosystem accounting is to isolate and record the ecosystem's contribution to the benefits received."
8. ¶18 SEEA EA, Table 6.3
9. ¶19 SEEA CF, para 3.186-3.188
0. ¶20 SEEA EA, para 6.47
1. ¶21 SEEA EA, Table 6.3, rows 12-13
2. ¶22 IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (2019); Mcleod et al. (2011) "A blueprint for blue carbon"
3. ¶23 SEEA EA, para 6.60
4. ¶24 SEEA EA, Table 6.3, row 10
5. ¶25 SEEA EA, para 6.36. "Ecosystem services encompass services that are both predominantly biotic… and predominantly abiotic (e.g. coastal protection services provided by sand dunes)."
6. ¶26 Ferrario et al. (2014) "The effectiveness of coral reefs for coastal hazard risk reduction and adaptation"; Beck et al. (2018) "The global flood protection savings provided by coral reefs"
7. ¶27 SEEA EA, Table 6.3, row 8
8. ¶28 SEEA EA, Table 6.3, row 14
9. ¶29 SEEA EA, para 6.25
0. ¶30 SEEA EA, Table 6.3, row 15
1. ¶31 SEEA EA, Table 6.3, row 9
2. ¶32 SEEA EA, para 6.48
3. ¶33 SEEA EA, Table 6.3, row 18
4. ¶34 SEEA EA, para 7.65
5. ¶35 SEEA EA, Table 6.3, row 19
6. ¶36 SEEA EA, Table 6.3, rows 21-22
7. ¶37 SEEA EA, Table 6.3, rows 20, 23
8. ¶38 SEEA EA, para 7.70
9. ¶39 2025 SNA, Figure 35.4 and Chapter 35, paras 35.1-35.10. The physical flow structure shows how natural inputs and residuals connect the environment and economy.
0. ¶40 SEEA CF, para 3.45
1. ¶41 SEEA CF, para 3.45. "Natural inputs are all physical inputs that are moved from their location in the environment as a part of economic production processes or are directly used in production."
2. ¶42 SEEA CF, para 5.393
3. ¶43 SEEA CF, para 5.429. "The SEEA CF recommends using gross catch rather than landings as the measure of extraction."
4. ¶44 SEEA CF, para 3.194-3.196
5. ¶45 SEEA CF, para 3.186
6. ¶46 SEEA CF, para 5.173
7. ¶47 SEEA Energy, para 1.27
8. ¶48 SEEA Energy Technical Note, para 13. "Energy from natural inputs comprise flows of energy from the removal and capture of energy from the environment by resident economic units."
9. ¶49 SEEA EA, para 1.79-1.82
0. ¶50 SEEA EA, para 1.81
1. ¶51 SEEA EA, para 1.81
2. ¶52 SEEA EA, para 7.31
3. ¶53 SEEA EA, para 1.82. Discards are included in gross catch (the extraction measure for asset accounts) and are also recorded as natural resource residuals (flows returned to the environment). The two recordings serve different

DRAFT

analytical purposes: gross catch captures the full pressure on fish stocks, while the natural resource residual records the portion returned to the environment.

4. ¶54 SEEA CF, Annex A5.4 and para 5.428. The catch concept hierarchy defines the progressive refinement from gross removal to nominal catch.
5. ¶55 UN SEEA EA (2021), para 4.34 and Table 4.2. The ecosystem type change matrix presents the area of different ecosystem types at the beginning of the accounting period (opening extent, rows) and at the end (closing extent, columns); off-diagonal cells record area converted between ecosystem types.
6. ¶56 UN SEEA EA (2021), para 4.35. Sum of cell entries in a row equals opening extent for that type (unchanged area plus reductions); sum of cell entries in a column equals closing extent (unchanged area plus additions). Where the EAA total area is unchanged between the two points in time, total row sums equal total column sums.
7. ¶57 UN SEEA EA (2021), para 4.23. Ecosystem conversions are situations in which, for a given location, there is a change in ecosystem type involving a distinct and persistent change in ecological structure, composition and function, which is reflected in the supply of a different set of ecosystem services.
8. ¶58 UN SEEA EA (2021), para 4.31. The structure of Table 4.1 (and by extension Table 4.2) allows for recording changes that are managed and unmanaged; an extension to the extent account may be developed to enable classification of ecosystem conversions by reasons for change (e.g., urban expansion, salinization, afforestation).
9. ¶59 SEEA CF, para 3.13
0. ¶60 SEEA CF, para 3.7
1. ¶61 SEEA EA, para 7.21-7.26
2. ¶62 SEEA EA Technical Recommendations, para 5.11
3. ¶63 Adapted from SEEA EA Figure 7.1
4. ¶64 SEEA EA, Table 7.1 and paras 7.21-7.33. The supply-use table structure extends the SNA supply-use framework to incorporate ecosystem assets as suppliers and ecosystem services as products.
5. ¶65 SEEA EA, para 7.27
6. ¶66 SEEA EA Technical Recommendations, para 5.23
7. ¶67 SEEA EA Technical Recommendations, para 5.22
8. ¶68 SEEA EA Technical Recommendations, para 5.23
9. ¶69 SEEA EA Technical Recommendations, Table 5.2
0. ¶70 SEEA EA, para 7.34
1. ¶71 SEEA EA Technical Recommendations, para 5.29
2. ¶72 SEEA EA, para 6.31
3. ¶73 SEEA EA Technical Recommendations, para 5.30
4. ¶74 SEEA EA, para 7.26. "In accounting terms, supply must equal use, the unit of measurement applied for each ecosystem service must be the same in both the supply and use account."
5. ¶75 UN-Habitat (2023). *World Cities Report*. Nairobi: UN-Habitat. Provides population and informal-settlement data and methodologies relevant to estimating beneficiary populations for coastal regulating services where standard survey frames undercount informal coastal communities. Compilers should also consult the most recent biennial edition of the *World Cities Report* and national census informal-settlement layers.
6. ¶76 SEEA EA, para 7.4. "The information on ecosystem services in physical terms can also be used to demonstrate the nature of the connection to the SNA production boundary."
7. ¶77 SEEA EA Technical Recommendations, Table 5.2 and 5.3
8. ¶78 Bradley, C., Taylor, S., Vardon, M., Lyons, M., Clement, S., & Obst, C. (2026). *Tracking nature dependencies and nature-related risks: integrated environmental-economic accounting in Australia* [Preprint, not peer reviewed; version 1, 19 September 2026], §4, p. 16. SocArXiv. https://doi.org/10.31235/osf.io/mq6bv_v1 (https://doi.org/10.31235/osf.io/mq6bv_v1). SEEA and SNA accounts are not well suited to tracking vulnerability; most vulnerability information sits in other statistics or needs separate analysis, such as of the substitutability of inputs.
9. ¶79 SEEA EA, para 8.1
0. ¶80 SEEA EA, para 8.20. "Exchange values are defined as the values at which goods, services, labour or assets are exchanged or could be exchanged for cash."
1. ¶81 SEEA EA, para 9.28
2. ¶82 SEEA CF, para 5.114-5.121
3. ¶83 SEEA CF, Figure 5.1 and Annex A5.1
4. ¶84 SEEA EA Technical Recommendations, para 5.94; SEEA Valuation Guidelines, para 664
5. ¶85 SEEA Valuation Guidelines, para 692
6. ¶86 SEEA EA, Chapter 9
7. ¶87 SEEA EA, para 9.50-9.52
8. ¶88 SEEA Valuation Guidelines, para 981
9. ¶89 SEEA Valuation Guidelines, para 973-977
0. ¶90 SEEA EA, para 9.53
1. ¶91 SEEA Valuation Guidelines, para 987
2. ¶92 SEEA EA, para 9.38-9.39
3. ¶93 SEEA EA, para 9.43

DRAFT

4. ¶94 SEEA EA, para 6.60
5. ¶95 SEEA Valuation Guidelines, para 791-820
6. ¶96 SEEA Valuation Guidelines, para 921-932
7. ¶97 SEEA Valuation Guidelines, para 805
8. ¶98 SEEA EA, para 9.40-9.42
9. ¶99 SEEA Valuation Guidelines, para 753-756
0. ¶100 SEEA EA, para 10.28-10.35
1. ¶101 SEEA EA, para 11.25-11.30
2. ¶102 SEEA EA, para 12.30

DRAFT

Economic Activity Relevant to the Ocean

Defines and measures the ocean economy using thematic and extended accounting principles, identifying ocean-related industries by standard industrial classification.

Version 0.8.1 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

OUTCOME

After completing this Circular, readers will be able to define and measure the ocean economy using thematic and extended accounting principles, identify ocean-related industries using the International Standard Industrial Classification (ISIC), compile supply and use tables for ocean economy sectors, and measure key aggregates including gross value added (GVA), employment, and the contribution of ocean activities to Gross Domestic Product (GDP). The guidance enables compilation of accounts that are consistent with the System of National Accounts 2025 (SNA 2025) and that integrate with the broader Ocean Accounts framework described in TG-0.1 General Introduction to Ocean Accounts and the statistical standards outlined in TG-0.2 Overview of Relevant Statistical Standards. This Circular supports the derivation of indicators for macro-level economic dependencies on the ocean (TG-2.2 Macro-level Dependencies), ocean economy structure (TG-2.5 Ocean Economy Structure), investment analysis (TG-2.6 Ocean Investment), and resource efficiency (TG-2.11 Resource Efficiency).

DRAFT

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 3
3.1 Why ocean economy accounts are compiled 3
3.2 Defining the Ocean Economy 3
3.3 Ocean Economy Thematic and Extended Accounts 7
3.4 Industry Classifications 8
3.5 Supply and Use Tables 10
3.6 Capital Formation in the Ocean Economy 12
3.7 Worked Example: Ocean Economy SUT for Country A 14
3.8 Treatment of Coastal Tourism 16
3.9 Integration with National SUTs 16
3.10 Extended Applications: Input-Output Analysis 16
Implementation Considerations 17
4. Acknowledgements 17
5. References 17

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Economic Activity Relevant to the Ocean (2026) (GOAP Technical Guidance on Ocean Accounting, TG-3.3, v0.8.1). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-3/3-3-economic-activity/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

1. Outcome

¶1 After completing this Circular, readers will be able to define and measure the ocean economy using thematic and extended accounting principles, identify ocean-related industries using the International Standard Industrial Classification (ISIC), compile supply and use tables for ocean economy sectors, and measure key aggregates including gross value added (GVA), employment, and the contribution of ocean activities to Gross Domestic Product (GDP). The guidance enables compilation of accounts that are consistent with the System of National Accounts 2025 (SNA 2025) and that integrate with the broader Ocean Accounts framework described in **TG-0.1 General Introduction to Ocean Accounts** and the statistical standards outlined in **TG-0.2 Overview of Relevant Statistical Standards**. This Circular supports the derivation of indicators for macro-level economic dependencies on the ocean (**TG-2.2 Macro-level Dependencies**), ocean economy structure (**TG-2.5 Ocean Economy Structure**), investment analysis (**TG-2.6 Ocean Investment**), and resource efficiency (**TG-2.11 Resource Efficiency**).

2. Requirements

¶1 **Essential prerequisites:**

- ¶2 **TG-0.1 General Introduction to Ocean Accounts**: conceptual framework and key components of Ocean Accounts
- ¶3 **TG-0.2 Overview of Relevant Statistical Standards**: international statistical standards underpinning ocean accounting

¶4 **Framework Position**

¶5 This Circular addresses the economic flows within the SNA production boundary (FG1). Ocean economy accounts measure production, income, supply/use, and capital flows that interact with SNA assets (E3). Economic activity also contributes to social conditions through employment and livelihoods (E5), whilst governance and institutional frameworks enable economic flows (E7). In the Ocean Accounts Framework (TG-0.1 Figure 0.1.2):

Edge	Direction	Description
E3	FG1 ↔ SG1	Monetary and physical flows between economic sectors and SNA assets (Applied)
E5	FG1 → SG2	Economic activities contributing to social conditions (Emerging)
Scope. TG-3.3 owns the ocean economy supply and use table and the aggregates derived from it — output, intermediate consumption, GVA, exports, GFCF — together with the ISIC and CPC concordance that delimits the ocean economy. It cross-refers for the indicators built on those aggregates to **TG-2.5**, for the sector-operational detail of individual ocean industries to Section 6, and for the survey and administrative sources that populate the table to **TG-4.2** and **TG-4.3**.		

¶6 | E7 | SG2 → FG1 | Social assets enabling economic flows (Emerging) |

DRAFT

3. Guidance Material

3.1 Why ocean economy accounts are compiled

¶1 Three families of decision drive demand for these accounts, and they shape compilation priorities. **Budget justification** requires the ocean economy's contribution to national income and employment, to weigh public expenditure on ocean management, fisheries governance, port infrastructure and marine environmental protection. **Economic planning** requires the relative importance of ocean industries, their productivity and capital intensity, and the trend in each. **Investment analysis and sustainable finance** require capital formation by ocean industry and its relationship to output growth.

¶2 Which account and which indicator answer each of these, and what an ocean economy figure can and cannot be used to claim, are set out in **TG-1.0 Ocean Accounting and the Blue/Ocean Economy**, whose Section 3.4 carries the routing table. This Circular supplies the account those decisions read: the boundary, the concordance, the supply and use table and the aggregates derived from it.

¶3 Terminology follows TG-1.0 Section 3.2. This Circular measures the **ocean economy**; the accounting framework below can accommodate a different definitional choice, provided the scope and boundaries adopted are documented.

3.2 Defining the Ocean Economy

¶1 The **ocean economy** (also referred to as the 'marine economy' or 'blue economy') comprises the economic activities that derive outputs from the ocean, use the ocean as an input to production, or provide goods and services directly to ocean-related activities[1]. This definition encompasses a spectrum from activities entirely dependent on the ocean (such as marine fishing) to activities that are partially ocean-related (such as coastal tourism, where visitors may engage in both marine and non-marine activities).

Conceptual boundaries

¶1 Defining the ocean economy requires clear boundaries around which activities are included. Following the ocean accounts framework in SEEA EA, the ocean economy can be understood in terms of three relationships between economic activities and the ocean[2]:

1. ¶2
   Ocean-dependent activities – activities that directly extract resources from, operate on, or harvest products from the ocean. These include marine fishing, aquaculture, offshore oil and gas extraction, sea and coastal water transport, and offshore renewable energy generation. These activities are intrinsically linked to the ocean and would not exist in its absence.
2. ¶3
   Ocean-related activities – activities that provide goods and services to ocean-dependent activities, or that process products originating from the ocean. These include shipbuilding and repair, fish processing, port and harbour operations, marine scientific research, and maritime education. The ocean is essential to these activities, though they do not operate directly on or in the ocean.
3. ¶4
   Partially ocean-related activities – activities where the ocean is one among several inputs or outputs. Coastal tourism is the primary example: visitors may stay in coastal accommodation and engage in marine recreation, but they also consume goods and services unrelated to the ocean. For these activities, the ocean economy accounts should estimate the share attributable to the ocean.

¶5 This three-tier categorisation aligns with approaches used by the OECD and various national ocean economy measurement programmes but is not a formally standardised classification. Countries may adapt these boundaries based on national circumstances and policy priorities, and should document the choices made to ensure transparency and comparability.

Operational decision rule for partially ocean-related activities

¶1 An activity is assigned to the 'partially ocean-related' tier when ocean-attributable revenue is a material share of establishment output. As an indicative materiality benchmark, this guidance suggests a figure of around 5 per cent of establishment output: activities whose ocean-attributable revenue falls well below this level are generally excluded from the ocean economy accounts rather than assigned a near-zero ratio. The 5 per cent figure is a pragmatic operational choice adopted by this guidance, not a value drawn from an external standard. SF-MST (paras 2.31–2.35) applies a qualitative 'significant share' criterion to identify tourism characteristic activities but does not specify a numeric threshold[3]. The 5 per cent benchmark operationalises that significance principle for the ocean economy context. SNA 2025 Chapter 38 para 38.8 notes that thematic accounts should focus on activities with material contributions to the phenomenon being measured. The benchmark is indicative rather than a rigid cut-off: compilers should apply judgement for activities close to the boundary and document the basis for inclusion or exclusion.

¶2 The following decision flowchart guides the classification of a candidate activity:

1. ¶3 Does the activity directly extract resources from, operate on, or harvest products from the ocean? **Yes** → Ocean-dependent (Tier 1, ratio = 1.0). **No** → proceed to step 2.
2. ¶4 Does the activity provide goods or services predominantly to ocean-dependent activities, or process ocean-origin products? **Yes** → Ocean-related (thematic scope, ratio estimated directly). **No** → proceed to step 3.
3. ¶5 Is ocean-attributable revenue a material share of establishment output (indicatively, around 5 per cent or more)? **Yes** → Partially ocean-related (Tier 1, ratio to be estimated). **No** → Exclude from ocean economy accounts.

¶6 Compilers should document the data source and methodology used to apply the materiality benchmark for each partially ocean-related industry included in their compilation, including any judgement exercised for activities close to the boundary. Figure 3.3.1 presents this three-gate routing as a decision tree. The Q3 materiality gate is the step most commonly misapplied.

DRAFT

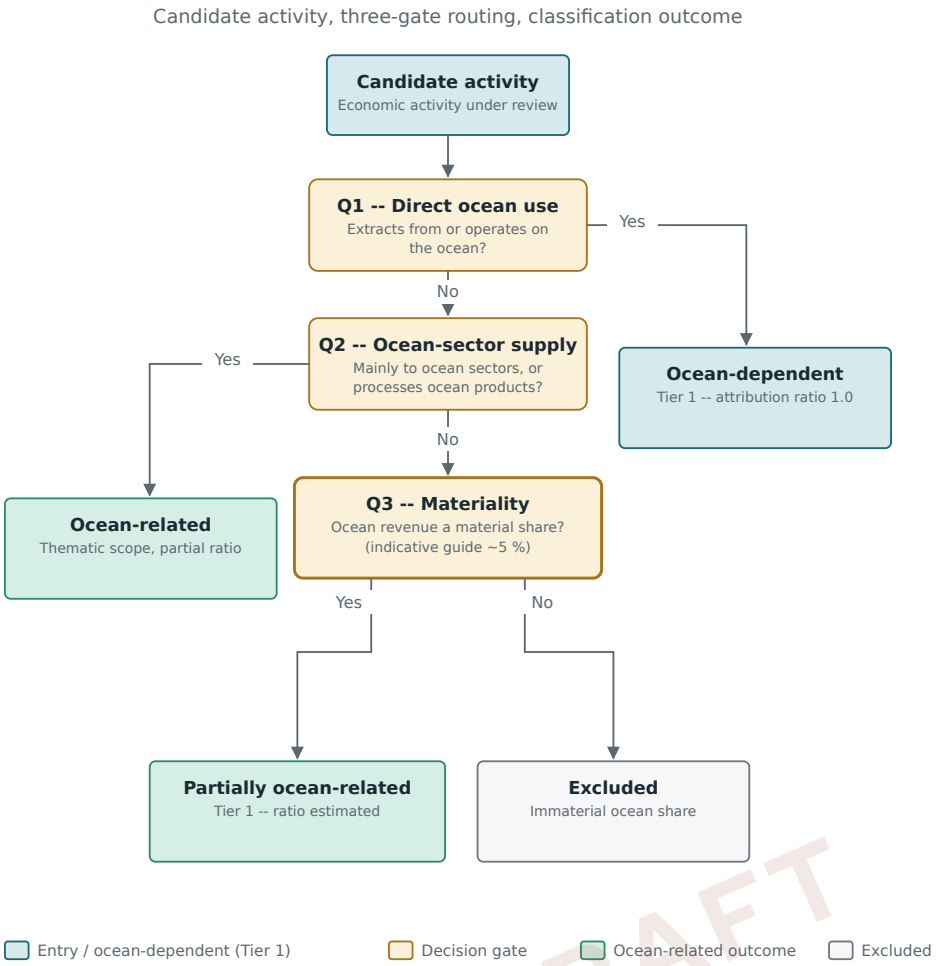


Figure 3.3.1 Three sequential gates route a candidate activity to ocean-dependent, ocean-related, partially ocean-related, or excluded. Q3 materiality uses an indicative 5% benchmark, not a hard cut-off; that gate is the most commonly misapplied.

Source: TG-3.3, operational decision rule for partially ocean-related activities (three-gate routing) and the indicative 5 % materiality benchmark.

Scope of the ocean economy

¶1 There is no single agreed definition of the ocean economy. Different institutions approach its scope differently, as analytical purposes and national circumstances vary. Conceptual frameworks for delineating the ocean economy typically include some or all of the following categories[4]:

1. ¶2 Economic activity physically located on the ocean (e.g., shipping, marine fishing, offshore energy extraction)
2. ¶3 Economic activity physically proximate to the ocean (e.g., coastal tourism, coastal aquaculture, port operations)
3. ¶4 Economic sectors on land that depend on natural inputs from the ocean (e.g., fish processing, construction materials derived from marine aggregates)
4. ¶5 Economic activity providing goods or services to ocean-based sectors (e.g., shipbuilding, marine engineering, maritime insurance)
5. ¶6 Market value of natural inputs derivable from SEEA CF monetary flow accounts, and market and non-market ecosystem service values derivable from SEEA EA supply accounts
6. ¶7 Indirect and intermediate expenditures on goods and services used by direct ocean activities (backward linkages through supply chains)
7. ¶8 Induced and final demand expenditures enabled by direct and indirect ocean activities (household spending from ocean economy wages and profits)

¶9 This seven-part framework synthesises approaches from multiple sources, including the OECD (2016), various national ocean economy programmes, and the broader environmental-economic accounting literature. It should be understood as a complementary applied categorisation, not a classification prescribed by the SEEA or SNA. Categories 1–4 define the core scope used by most national ocean economy programmes. Categories 5–7 extend the measurement boundary for advanced analytical applications.

¶10 The first four categories correspond broadly to the direct economic activities that form the core of most national ocean economy measurement programmes. Categories five through seven extend the measurement boundary: category five captures ecosystem contributions, category six supply chain linkages, and category seven macroeconomic multiplier effects. The specific categories included in any particular compilation depend on data availability, analytical objectives, and the accounting frameworks employed. Figure 3.3.2 sets out how the seven categories map onto the Tier 1 / Tier 2 boundary. The double-rule marks the prohibition on summing the SNA-comparable core (categories 1–4) with the extension (categories 5–7). The relationship between ecosystem service values (category five) and economic activity is addressed further in **TG-2.4 Ecosystem Goods and Services** and **TG-3.2 Flows from the Environment to the Economy**.

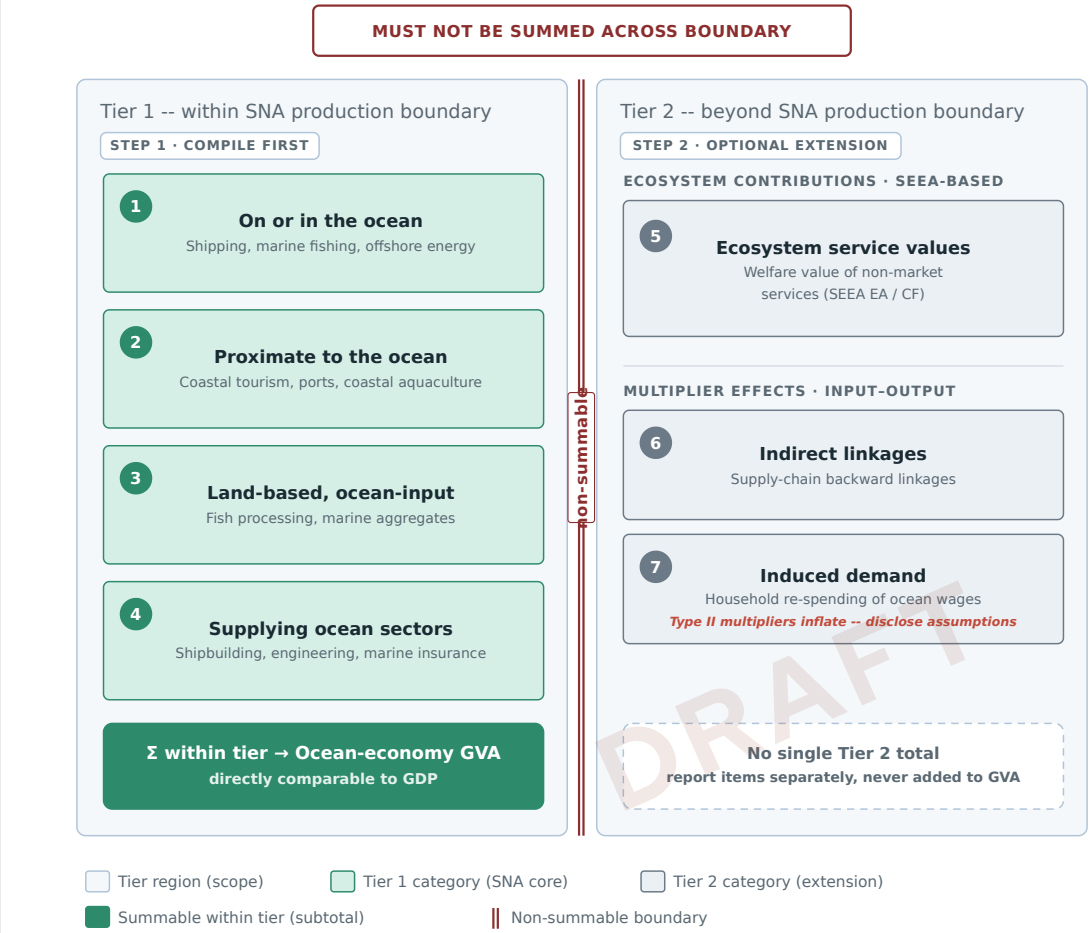


Figure 3.3.2 The Tier 1 / Tier 2 split is the SNA production boundary: Tier 1 and Tier 2 must never be summed together. Tier 1 sums within-tier to GDP-comparable ocean-economy GVA; Tier 2 items are optional extensions reported separately.

Source: TG-3.3 §"Scope of the ocean economy" (seven-category framework and tiered implementation note); multiplier caveat per TG-3.3 Section 6.

¶11 The 2025 SNA supports the compilation of **thematic and extended accounts** (formerly known as satellite accounts) for the ocean economy. Chapter 38 of the SNA 2025 describes thematic and extended accounts as "flexible tools for increasing the visibility of key phenomena by bringing all the pertinent data together in one place" (para 38.2)[5]. The SNA distinguishes the two (para 38.6): thematic accounts disaggregate and rearrange items within the integrated framework of the SNA, whilst extended accounts expand or modify the boundaries applied in that framework to give a fuller view of a phenomenon. Ocean economy measurement typically involves both: thematic accounts that provide detailed breakdowns of ocean-related industries within the existing national accounts framework, and extended accounts that incorporate ecosystem service values or other elements beyond the standard SNA production boundary. The SNA 2025 explicitly identifies oceans as an area where the core ecosystem accounting framework can be applied using thematic and extended accounting principles (para 35.63), and SEEA Ecosystem Accounting describes thematic accounting for oceans as a specific application (para A1.135)[6].

Spatial considerations

¶1 The spatial dimension of the ocean economy intersects with the concept of Economic Exclusive Zones (EEZs) established under the United Nations Convention on the Law of the Sea (UNCLOS)[7]. A country's ocean economy includes:

- ¶2 Activities occurring within its territorial waters and EEZ

- ¶3 Activities by resident enterprises operating in international waters (such as distant-water fishing fleets), recorded as production of resident units
- ¶4 Coastal and land-based activities that serve ocean-related purposes (such as ports and fish processing plants)

¶5 Activities by non-resident units operating within a country's EEZ under licence or quota arrangements require careful treatment. The SNA 2025 addresses this specifically: when non-resident units make use of quota established for fishing in a country's EEZ, the coastal state is treated as owning the fish stocks, with the licence fees representing rent payments from the non-resident fishing enterprise to the coastal state [8].

¶6 For areas beyond national jurisdiction (ABNJ), the entry into force of the BBNJ Agreement on 17 January 2026 may provide new frameworks for statistical treatment as governance arrangements develop [9]. Compilers should monitor developments in this area. Data considerations for ABNJ are addressed in **TG-6.6 Deep-Sea and ABNJ**.

The inland boundary

¶7 The geographic definition of the ocean economy requires an inland boundary as well as a seaward one, and the inland boundary is the country-specific decision of the two. It involves choices about the distance from the shoreline at which activity ceases to be counted, the extent of the coastal zone definition applied, the inclusion of rivers, estuaries and deltas where ocean-dependent activity occurs, and whether large inland bodies of water are included. The United States Marine Economy Satellite Account, which includes the Great Lakes, is the most-cited instance of the last of these. There are no universally correct answers to these choices, and the scope decisions of three national programmes in **TG-1.0** Section 3.6 show how legitimately they vary.

¶8 Two requirements follow. The boundary adopted should be documented explicitly and applied consistently across time periods, as an inland boundary that moves between periods makes a trend series uninterpretable. It should also be disclosed in the metadata accompanying any published aggregate: differences in inland boundary choice are a primary source of cross-country non-comparability, and a figure that does not state its inland boundary cannot be compared with another country's [10].

Relationship to ecosystem services

¶1 The ocean economy as defined here is distinct from the ecosystem services supplied by marine ecosystems, though the two are related. Ecosystem services represent the contributions of ecosystems to economic activity and human well-being [11]. The ocean economy, in contrast, represents the economic activities themselves. Fish harvested from the ocean represents an ecosystem service (biomass provisioning). The fishing industry that conducts the harvest is part of the ocean economy. The link between these concepts is addressed in **TG-2.4 Ecosystem Goods and Services** and **TG-3.2 Flows from the Environment to the Economy**.

3.3 Ocean Economy Thematic and Extended Accounts

¶1 The most statistically consistent approach to measuring the ocean economy applies **thematic and extended accounting** principles from the System of National Accounts. The SNA 2025 describes these as accounts that provide complementary data allowing insight into a key activity or aspect of the economy that lacks visibility in the integrated framework of national accounts (formerly known as 'satellite accounts') [12]. The Tourism Satellite Account (TSA) [13] provides a well-established model that has been adapted for ocean economy measurement in several countries.

¶2 Ocean economy measurement and tourism measurement are closely analogous. In both frameworks, economic activity is defined by its relationship to a particular domain (the ocean or tourism), which industry classification alone does not capture. Tourism measurement delineates a functional segment of the economy that cuts across multiple ISIC industries: tourists consume accommodation services, food services, transport services, and recreation services, none of which is exclusively a tourism industry. The ocean economy likewise encompasses marine fishing, offshore energy, maritime transport, shipbuilding, port operations, coastal tourism, and marine research, all distributed across multiple ISIC divisions. The concept of 'tourism characteristic products' and 'tourism characteristic activities' from the SF-MST (paras 2.33–2.35) [14] translates directly to the ocean economy context as 'ocean-characteristic products' and 'ocean-characteristic activities'.

Principles of thematic and extended accounting

¶1 Thematic and extended accounts for the ocean economy follow four principles derived from the SNA [15]:

1. ¶2
   Conceptual consistency — the thematic account uses the same concepts and definitions as the SNA (output, intermediate consumption, value added, employment), so that ocean economy measures are consistent with and comparable to broader economic statistics.
2. ¶3
   Flexible boundaries — whilst maintaining conceptual consistency, the extended account can expand boundaries to include activities or products that merit special focus for analytical purposes, such as non-market ecosystem services or unpaid household production in coastal communities.
3. ¶4
   Characteristic products and activities — following the TSA approach, ocean economy accounts identify 'ocean-characteristic products' (goods and services whose production depends on the ocean) and 'ocean-characteristic activities' (industries whose output consists predominantly of ocean-characteristic products).
4. ¶5
   Supply and use framework — the thematic account organises data in a supply and use table framework that reconciles the supply of ocean-characteristic products with their use, enabling derivation of consistent estimates of ocean economy output, value added, and employment.

DRAFT

Structure of ocean economy thematic and extended accounts

¶1 An ocean economy thematic account typically comprises the following components[16]:

¶2 **Production accounts by ocean industry** — for each ocean-related industry, recording output, intermediate consumption, and gross value added. These accounts follow the structure of SNA production accounts but provide detail for ocean-specific industries that may be aggregated in standard national accounts.

¶3 **Supply table for ocean-characteristic products** — recording the supply of ocean-characteristic products by producing industry (ocean and non-ocean industries), imports, and adjustments for taxes less subsidies and trade margins.

¶4 **Use table for ocean-characteristic products** — recording the use of ocean-characteristic products as intermediate consumption by industry, final consumption by households and government, gross fixed capital formation, and exports.

¶5 **Employment accounts** — recording the number of persons employed, jobs, hours worked, and full-time equivalent employment in ocean industries, potentially disaggregated by occupation, status in employment, and demographic characteristics. See International Recommendations for Tourism Statistics 2008 Chapter 7 for methodological guidance on employment measurement in sector thematic accounts[17].

¶6 **Gross fixed capital formation** — recording investment in ocean-related produced assets, including vessels, port infrastructure, aquaculture facilities, and offshore platforms.

¶7 **Connection to wider accounts** — documenting the relationship between ocean economy aggregates and national totals, including the ocean economy's share of GDP, employment, and exports.

¶8 The Classification of the Functions of Government (COFOG) identifies government expenditure on ocean-related functions, such as environmental protection of marine areas, fisheries management, and maritime safety. This expenditure data complements the production-focused thematic accounts described above. Linking COFOG-classified government expenditure with ocean economy production accounts supports analysis of public spending in relation to ocean economic activity. Detailed guidance on integrating government fiscal data with ocean accounts is provided in **TG-1.1 Budget Processes**.

Ocean economy indicators

¶1 The headline measures derived from these accounts — ocean economy GVA, employment, share of GDP, share of employment, exports and investment — together with their derivation and interpretation, are **TG-2.5 Structure and Function of the Ocean Economy**. This Circular produces the aggregates they are computed from; it does not restate them.

3.4 Industry Classifications

¶1 The identification and classification of ocean-related industries underpins the compilation of ocean economy accounts. The **International Standard Industrial Classification of All Economic Activities (ISIC)** provides the internationally agreed framework for classifying economic activities by industry[18]. ISIC Revision 4 remains the current international standard widely implemented in national statistics, although ISIC Revision 5 was endorsed by the UN Statistical Commission in March 2024 with implementation expected from 2027.

¶2 ISIC Rev.5 was endorsed by the UN Statistical Commission in March 2024, but full implementation in national statistical systems typically requires several years of preparatory work including development of national adaptations, correspondence tables, and back-casting of historical series. Compilers should ascertain which version of ISIC (or its national adaptation) is currently in use in their country's business register and economic surveys, and use the relevant correspondence tables when mapping between ISIC versions[19].

Core ocean industries

¶1 The following ISIC Rev.4 categories represent the core ocean-dependent industries[20]:

¶2 **Division 03 — Fishing and Aquaculture**

- ¶3 Class 0311 Marine fishing — fishing on a commercial basis in ocean and coastal waters, including taking of marine crustaceans, molluscs, and other marine organisms
- ¶4 Class 0312 Freshwater fishing — included when freshwater systems connect to marine environments or support anadromous species
- ¶5 Class 0321 Marine aquaculture — farming of marine fish, crustaceans, molluscs, seaweed, and other aquatic organisms in marine or brackish waters
- ¶6 Class 0322 Freshwater aquaculture — may be relevant for integrated coastal aquaculture systems

¶7 **Division 50 — Water Transport**

- ¶8 Group 501 Sea and coastal water transport
  - ¶9 Class 5011 Sea and coastal passenger water transport — including ferries, cruise ships, and excursion boats
  - ¶10 Class 5012 Sea and coastal freight water transport — including container shipping, tankers, and bulk carriers
- ¶11 Group 502 Inland water transport — relevant where inland waterways connect to marine transport systems

¶12 **Division 06 — Extraction of Crude Petroleum and Natural Gas**

- ¶13 Class 0610 Extraction of crude petroleum — includes offshore oil extraction
- ¶14 Class 0620 Extraction of natural gas — includes offshore gas extraction
- ¶15 Class 0910 Support activities for petroleum and natural gas extraction — includes offshore support services

¶16 **Division 35 — Electricity, Gas, Steam and Air Conditioning Supply** (partial)

DRAFT

- ¶17 Class 3510 Electric power generation, transmission and distribution — includes offshore wind, tidal, and wave energy generation (requires disaggregation from land-based generation)

¶18 Specific guidance on offshore energy accounting is provided in **TG-3.10 Offshore Energy**.

Ocean-related industries

¶1 Additional industries are partially ocean-related and require estimation of their ocean-related share [21]:

¶2 **Manufacturing**

- ¶3 Class 1020 Processing and preserving of fish, crustaceans and molluscs
- ¶4 Class 3011 Building of ships and floating structures
- ¶5 Class 3012 Building of pleasure and sporting boats
- ¶6 Class 3315 Repair of transport equipment (partial — for ship repair)

¶7 **Transportation and storage**

- ¶8 Class 5222 Service activities incidental to water transportation — including port and harbour operations, navigation, pilotage, and lighterage
- ¶9 Class 5224 Cargo handling (partial — for port cargo handling)
- ¶10 Class 5229 Other transportation support activities (partial — for marine support services)

¶11 **Accommodation and food service activities**

- ¶12 Class 5510 Short-term accommodation activities (partial — coastal tourism accommodation)
- ¶13 Class 5520 Camping grounds, recreational vehicle parks and trailer parks (partial — coastal facilities)

¶14 **Professional, scientific and technical activities**

- ¶15 Class 7110 Architectural and engineering activities (partial — marine engineering)
- ¶16 Class 7210 Research and experimental development on natural sciences and engineering (partial — marine research)

¶17 **Public administration**

- ¶18 Class 8423 Public order and safety activities (partial — coast guard, maritime enforcement)
- ¶19 Class 8421 Foreign affairs (partial — maritime boundary administration)

¶20 **Education**

- ¶21 Class 8530 Higher education (partial — maritime education and training)

¶22 **Arts, entertainment and recreation**

- ¶23 Class 9319 Other sports activities (partial — marine recreation including sport fishing)

¶24 **Emerging sectors and blue technology.** Innovative ocean technologies — including marine renewables, marine biotechnology, robotic marine vehicles, and advanced ICT applications in marine contexts — are often not yet codified in ISIC and may be small relative to core sectors in the early years of production. Best practice, consistent with EU and OECD approaches, is to report these sectors separately from core accounts at a level of detail appropriate to available information, rather than integrating them into existing ISIC classes where no code exists [10].

Determining ocean-related shares

¶1 For industries that are only partially ocean-related, the ocean economy share — the **ocean ratio** — must be estimated. It is directly analogous to the 'tourism ratio' of the SF-MST (paras 4.50–4.53), which estimates the share of an industry's output attributable to tourism demand [22]. **This subsection is the single source for ocean-ratio estimation across the publication**; TG-2.2, TG-2.5 and TG-2.11 apply the ratios derived here and do not restate the method.

¶2 **Choose the method by the data source available, in this order.** The ordering is by directness of evidence, not by convenience: each level down substitutes inference for observation, and the level used must be recorded per industry in the metadata [23].

Level	Data source	What it gives	Marine examples
1. Establishment survey	Establishment-level returns that separately identify ocean-related activity within a mixed industry	The ratio directly, at establishment level	A dedicated ocean-economy survey, or an ocean-relationship question added to the national business survey
2. Administrative or revenue records	Enterprise tax records, business registers, licensing and permit systems recording ocean-specific revenue or activity	An observed revenue or activity share	Coastal accommodation revenue from beach-facing properties; share of offshore drilling permits; cargo tonnage through marine ports; vessel registrations
3. Geospatial proxy	Establishment location intersected with a coastal or marine boundary	An inferred share from location	GIS coastal-proximity buffers applied to the business register; proportion of a commodity's output sourced offshore
4. Structured expert judgement	A documented, iterative process with independent high and low estimates converging over anonymous rounds (Delphi)	A defensible starting point, with a commitment to refine	Any industry where levels 1–3 are unavailable

¶3 **Default allocation key where an enterprise straddles the boundary.** A single enterprise may span ocean and non-ocean activity under one ISIC code — a processor handling both marine and freshwater species, a coastal energy company with off-

DRAFT

shore and onshore operations. The recommended default key is **revenue share from ocean versus non-ocean sales** in the reference year: a processor deriving 70 per cent of revenue from marine species attributes 70 per cent of its GVA to the ocean economy. Whichever key is chosen must be documented and applied consistently across the entire time series; changing it between years introduces a structural break that must be flagged in the metadata.

¶4 **Indicative starting ranges, where nothing better exists.** These are pragmatic anchors for a first compilation at level 4, not standards-derived values, and they should be replaced as soon as level 1–3 data become available. Fish processing (ISIC 1020): **0.70–0.90**, reflecting typical industry structures in small island and coastal states. Coastal accommodation (ISIC 5510): **0.30–0.50**. Ratios outside these ranges require additional justification in the metadata.

¶5 **Identify the sources of partials before finalising industry selection.** The availability of reliable partial-estimation data should influence which industries are included in the accounts — not the reverse. Underlying data sources and allocation rules for all partials should be published alongside the results to support replication and cross-country comparison.

¶6 **Employment measure.** Where ocean employment is compiled, the primary measure is **headcount** (persons employed in the reference period), consistent with what labour force surveys typically support. Report **full-time equivalent (FTE)** employment additionally where source data permit, in line with the SNA 2025 recommendation that FTE is preferred for comparability where part-time and seasonal work is significant. FTE matters most for coastal accommodation, tourism-related and small-scale fisheries activity. The chosen measure must be applied consistently to both numerator and denominator of any employment share, and documented.

¶7 The approach for tourism follows the Tourism Satellite Account methodology, where the 'tourism ratio' concept is adapted to estimate the share of tourism industries attributable to coastal and marine tourism[24], [25]. Detailed guidance on survey methods is in **TG-4.2 Survey Methods for Ocean Economic Activity**, and on administrative data sources in **TG-4.3 Administrative Data Sources**. Multi-agency compilation has been demonstrated in practice: Canada's marine economy accounts draw on Fisheries and Oceans Canada, Natural Resources Canada, Transport Canada and Statistics Canada.

3.5 Supply and Use Tables

¶1 **Supply and use tables** (SUTs) provide the integrating framework for ocean economy accounts. SUTs record the supply of products (from domestic production and imports) and their use (as intermediate consumption, final consumption, capital formation, or exports), so that total supply equals total use for each product[26]. The SNA 2025 Chapter 15 sets out the structure, compilation, and balancing of supply and use tables in detail.

Structure of ocean economy SUTs

¶1 An ocean economy supply table records, for each ocean-characteristic product:

- ¶2 Output by ocean industries
- ¶3 Output by non-ocean industries (where applicable)
- ¶4 Imports of the product
- ¶5 Trade and transport margins
- ¶6 Taxes less subsidies on products
- ¶7 Total supply at purchasers' prices

¶8 An ocean economy use table records, for each ocean-characteristic product:

- ¶9 Intermediate consumption by ocean industries
- ¶10 Intermediate consumption by non-ocean industries
- ¶11 Final consumption expenditure by households
- ¶12 Final consumption expenditure by government
- ¶13 Gross fixed capital formation
- ¶14 Changes in inventories
- ¶15 Exports
- ¶16 Total use at purchasers' prices

Compilation procedure for ocean economy SUTs

¶1 The compilation process follows SNA 2025 Chapter 15 guidance and adapts the tourism measurement approach from the SF-MST[27]. The following steps provide a systematic procedure:

¶2 **Step 1: Identify ocean economy industries via ISIC concordance**

¶3 Using the industry categorisation in Section 3.4 above and the ISIC-ocean economy concordance in Table 2 below, identify all ISIC Rev.4 classes that constitute the ocean economy in the compiling country. For each class, determine whether it is wholly ocean-dependent (ocean ratio = 1.0) or partially ocean-related (ocean ratio < 1.0). This classification corresponds to the identification of 'tourism characteristic activities' in the SF-MST framework[28].

¶4 **Step 2: Identify ocean-characteristic products via CPC concordance**

¶5 Determine which products are wholly or partially ocean-characteristic, using the Central Product Classification (CPC) aligned with ISIC industry classifications. Ocean-characteristic products include:

- ¶6 **Fish and fishery products** — Live fish and other fishing products (CPC Division 04); Processed and preserved fish products (CPC Group 212)

DRAFT

- ¶7 **Marine transport services** – Sea and coastal water transport services (CPC Divisions 65–67); Port services, pilotage, and lighterage
- ¶8 **Offshore extraction products** – Crude petroleum from offshore sources; Natural gas from offshore sources; Offshore mineral products
- ¶9 **Marine tourism and recreation services** – Coastal accommodation services (partial); Marine recreational services

¶10 **Step 3: Extract ocean economy sub-matrices from national SUTs**

¶11 From the balanced national supply and use tables, extract the columns corresponding to identified ocean economy industries and the rows corresponding to ocean-characteristic products. This creates ocean economy supply and use tables that are subsets of the national tables (SNA 2025 Chapter 15, para 15.9). If the national SUTs are published at a level of aggregation above individual ISIC classes, compilers may need to use supplementary data sources—business surveys (**TG-4.2**) and administrative records (**TG-4.3**)—to disaggregate the relevant columns and rows.

¶12 **Step 4: Determine ocean economy ratios**

¶13 For partially ocean-related industries, estimate the ocean ratio using the method hierarchy, the default allocation key and the indicative ranges in Section 3.4 above. Record the level used for each industry in the metadata.

¶14 **Step 5: Balance the ocean economy SUT**

¶15 Reconcile supply and use for each ocean-characteristic product, resolving discrepancies through quality assessment and adjustment. The balancing process improves the consistency and reliability of the accounts. SNA 2025 Chapter 15 (paras 15.130–15.139) provides detailed guidance on balancing procedures, including use of commodity flow methods, confrontation of supply and demand estimates, and iterative adjustment.

¶16 **Step 6: Derive GVA, employment, trade aggregates**

¶17 From balanced ocean economy SUTs, derive gross value added by industry (output less intermediate consumption), total ocean economy GVA, ocean economy employment, ocean economy exports, and ocean economy GFCF:

¶18

$$\text{Ocean Economy Direct GVA} = \sum_i (\text{GVA}_i \times \text{Ocean ratio}_i)$$

¶19 Summing GVA rather than output avoids double-counting inter-industry transactions by construction: the supply-use identity has already netted each industry's intermediate purchases out of its value added, so marine fishing (ISIC 0311) and fish processing (ISIC 1020) may both be included without double-counting the seafood supply chain.

¶20 **Step 7: Adjust for taxes less subsidies on products**

¶21 To derive Ocean Economy Direct GDP from Ocean Economy Direct GVA, add the ocean-related share of taxes less subsidies on products:

¶22

$$\text{Ocean Economy Direct GDP} = \text{Ocean Economy Direct GVA} + \text{Ocean share of (taxes} - \text{subsidies on products)}$$

¶23 The ocean share of product taxes and subsidies can be estimated in proportion to the ocean economy's share of total final expenditure on ocean-characteristic products.

¶24 These aggregates provide the foundation for the structural indicators in **TG-2.5 Ocean Economy Structure**, the dependency indicators in **TG-2.2 Macro-level Dependencies**, and the efficiency indicators in **TG-2.11 Resource Efficiency**.

Ocean economy supply-use table template

¶1 Table 1 provides a template for the ocean economy supply-use table in monetary terms. The supply table records the output of ocean-related products by ocean industries, whilst the use table records the intermediate consumption, final demand, and value added for each industry. This template follows the structure established in SNA 2025 Chapter 38 for thematic and extended accounts [29].

¶2 **Table 1: Ocean Economy Supply-Use Table Template (Basic Prices, currency units)**

¶3 **SUPPLY TABLE**

Product	Marine Fishing	Aquaculture	Shipping	Ports	Tourism	Other Ocean	Non-Ocean	Imports	Total Supply
Fish products									
Transport services									
Tourism services									
Port services									
Energy products									
Other products									
Total output									

DRAFT

¶4 **USE TABLE**

Product	Marine Fishing	Aquaculture	Shipping	Ports	Tourism	Other Ocean	Non-Ocean	Households	Govt	GFCF	Ex
Fish products											
Transport services											
Tourism services											
Port services											
Energy products											
Other products											
Total intermediate											
GVA											
Total output											

¶5 The supply-use identity requires that Total Supply = Total Use for each product. GVA for each industry provides the primary measure of the ocean economy's contribution to GDP.

ISIC–ocean economy concordance

¶1 Table 2 maps ISIC Rev.4 industry codes to ocean economy activities, identifying the relationship type and recommended estimation approach. This concordance supports the identification and measurement of ocean industries within existing national statistical frameworks [30].

ISIC Rev.4	Description	Ocean Relationship	Allocation key where partial	Preferred data source for the key
0311	Marine fishing	Ocean-dependent (100%)	n/a	Catch statistics
0312	Freshwater fishing	Excluded	n/a	n/a
0321	Marine aquaculture	Ocean-dependent (100%)	n/a	Aquaculture production statistics
0322	Freshwater aquaculture	Excluded	n/a	n/a
5011	Sea passenger transport	Ocean-dependent (100%)	n/a	Transport statistics
5012	Sea freight transport	Ocean-dependent (100%)	n/a	Transport statistics
0610	Crude petroleum extraction	Partial (offshore share)	Production volume share, offshore vs onshore	Petroleum regulator or enterprise records
0620	Natural gas extraction	Partial (offshore share)	Production volume share, offshore vs onshore	Petroleum regulator or enterprise records
3510	Electric power generation, transmission and distribution	Partial (offshore wind/tidal)	Generation capacity or output share	Energy regulator; generation licences
1020	Fish processing	Partial (may include freshwater species)	Revenue share, marine vs freshwater raw material	Enterprise survey or administrative records
3011	Ship building	Ocean-related	Direct, where the yard is marine-only	Business register
5222	Water transport support	Ocean-related	Direct	Port authority records
5510	Accommodation	Partial (coastal tourism)	Revenue share from marine tourism demand	Tourism surveys; coastal visitor statistics
9319	Sports activities	Partial (marine recreation)	Participation or revenue share	Tourism surveys

DRAFT

¶2 *Table 2: ISIC Rev.4 to ocean economy concordance, with the allocation key and preferred data source for each partially ocean-related class. Illustrative: compilers should develop a country-specific concordance adapted to their national industry classification, and record the estimation level from Section 3.4 for each partial.*

¶3 For 'ocean-dependent' industries (100% attributable), the full output of the ISIC class is included. For 'partial' industries, the ocean share must be estimated using supplementary data such as administrative records or surveys. For 'ocean-related' industries, professional judgement and data analysis determine inclusion.

3.6 Capital Formation in the Ocean Economy

¶1 Gross fixed capital formation (GFCF) in ocean industries, and expenditure on marine environmental protection, are compiled on the same industry basis as the ocean economy SUT above. This section specifies the classification decisions those compilations require. The **indicators** derived from them — public and private investment indicators, sustainable ocean finance, tracking methodology — are **TG-2.6 Ocean Investment**.

Scope tiers for an investment compilation

¶1 To support consistent application of the three-category framework, the basic/intermediate/extended tiered framing used elsewhere in this Circular applies:

- ¶2 **Basic (minimum required) scope.** A baseline ocean investment compilation must cover (i) ocean economy capital formation (GFCF by enterprises and government in ocean industries) and (ii) environmental expenditure for ocean protection. These two categories anchor the compilation in the SNA institutional sector accounts, specifically the capital account of non-financial corporations and general government (SNA 2025 Chapter 11) and the environmental protection expenditure account (EPEA) of the SEEA Central Framework.
- ¶3 **Intermediate scope.** Adds public-enterprise GFCF straddling the corporate and government sectors (e.g., state-owned port authorities, national fisheries enterprises), recorded against the appropriate SNA institutional sector. This is recommended where public enterprises are material to ocean investment.
- ¶4 **Extended scope.** Adds sustainable ocean finance as a supplementary classification of financial instruments (debt securities, loans, equity, investment fund shares) following the "of which" reporting structure in SNA 2025 Table 35.3. This tier is recommended for countries with active sustainable finance markets or sovereign blue bond programmes.

¶5 Adoption of a tier beyond basic should be documented in the methodological notes. Compilers using only the basic tier should not present the resulting table as exhaustive of ocean-related investment.

¶6 These scope tiers describe *what to measure*. They are distinct from, and orthogonal to, the data-maturity compilation pathway in **TG-2.6** Section 3.5 (Foundational, Developing, Advanced), which describes *what a compiler can produce given available data*. A country at an early data-maturity stage may still target extended scope. The two axes should not be conflated.

Restoration expenditure: capitalisation decision tree

¶1 The SNA treatment of restoration expenditure (mangrove planting, reef restoration, seagrass replanting) is recorded in **TG-2.6 Ocean-related Investment** Table 1 as "varies by nature of expenditure." To support consistent classification, compilers should apply the following three-question decision tree before recording restoration expenditure as either GFCF or current expenditure:

1. ¶2 **Is the resource cultivated or natural?** Cultivated biological resources (e.g., a managed mangrove plantation intended to yield future services such as coastal protection, carbon storage, or fishery support) can give rise to produced assets. Wholly natural resources fall outside the SNA production boundary as produced assets. Restoration expenditure on them is recorded as current expenditure (or, in extended SEEA EA accounts, against the ecosystem asset).
2. ¶3 **Is there an identifiable asset whose value will accrue over multiple periods?** Capitalisation requires an asset that delivers benefits over more than one accounting period. Project-based plantings managed under a maintenance plan typically meet this test, whilst one-off cleanup events do not.
3. ¶4 **Who holds economic ownership of the restored resource?** Economic ownership means the right to claim benefits and bear risks, and that ownership must rest with an identifiable institutional unit for GFCF treatment to apply (SNA 2025 Chapter 11, the capital account, which defines the economic owner as the unit entitled to claim the benefits of using an asset by virtue of accepting the associated risks). Where the restored resource is on commons or in areas beyond clearly assigned ownership, current expenditure treatment applies.

DRAFT

¶5 For the non-produced asset dimension (treatment of the ecosystem itself), compilers should consult SNA 2025 Chapter 11 on biological resources and the SEEA Ecosystem Accounting (SEEA EA) Chapter 3 on ecosystem asset delineation, with monetary asset and restoration treatment elaborated in SEEA EA Chapters 10–12.

Residence and economic ownership for ocean assets

¶1 Investment measurement follows the residence principle of the SNA, attributing investment to the economic territory where the producing unit is resident. The governing attribution principle is economic ownership: the residence of the institutional unit that bears the economic risk and reward associated with the asset, not the flag of registration. For ocean activities, this creates specific considerations:

- ¶2 Investment in vessels operated by a resident economic owner is attributed to the country of residence of that owner, regardless of the flag under which the vessel is registered.
- ¶3 Offshore installations within a country's Exclusive Economic Zone (EEZ) are treated as being within the economic territory of the coastal state.
- ¶4 Investment by non-resident enterprises operating under licence within the EEZ (such as foreign fishing fleets) is attributed to the country of residence of the enterprise.

¶5 **Worked example — flags of convenience.** A vessel legally registered in Country A (an open registry), economically owned by an enterprise resident in Country B, and operated under a bareboat charter to a fishing company resident in Country C, is attributed to Country B for GFCF purposes, as Country B's enterprise bears the economic risk and holds title to the asset. Country A records no GFCF for the vessel. Its open-registry function does not confer economic ownership. For compilers in jurisdictions with large open registries or large beneficial-ownership shipping sectors, this distinction is material. See BPM7 Chapter 4 (Institutional Units and Sectors, Economic Territory, and Residence), paragraphs 4.214–4.220, for the corresponding treatment in external sector statistics.

¶6 The treatment of maritime investments has been clarified in SNA 2025, which provides guidance on the economic ownership of ships and offshore structures [31]. For areas beyond national jurisdiction (ABNJ), the 2025 SNA notes that "where there is interest in organising data about these types of natural capital outside of the scope of the integrated framework of the SNA … the accounting definitions and treatments of the integrated framework of the SNA and the SEEA can be applied" [32]. That approach is relevant for investment in activities spanning EEZ and high seas areas. The entry into force of the BBNJ Agreement on 17

January 2026 may introduce new governance arrangements with implications for statistical treatment of investment in ABNJ. Compilers should monitor developments in this area and consult **TG-6.6 Deep-Sea and ABNJ** for further guidance on accounting for activities in these zones[33].

¶7 **Interim guidance for ABNJ-adjacent investment.** Pending updated guidance from GOAP or the UN Statistics Division on BBNJ-related statistical treatment, compilers preparing 2025 and 2026 ocean accounts should:

1. ¶8 Apply the SNA residence principle as the default rule: investment in ABNJ-related activities (deep-sea mining, high-seas fishing, BBNJ-linked biodiversity offset instruments) is attributed to the economic territory of the investing institutional unit.
2. ¶9 Flag ABNJ-related investment as a separate memorandum item beneath the main ocean investment totals, so that future revision is straightforward when authoritative guidance is issued.
3. ¶10 Retain full documentation of classification decisions (instrument, activity location, residence determination, taxonomy applied) to enable retrospective revision.

Classification rule: avoiding double-count between GFCF and EPEA

¶1 Several categories of ocean-related public spending, in particular coastal protection structures (sea walls, groynes, beach nourishment), could plausibly be classified under both government GFCF in ocean industries and environmental protection expenditure for ocean protection. To prevent double counting, compilers should apply the following classification rule:

- ¶2 **GFCF is classified by the primary purpose of the asset**, following the COFOG purpose-of-expenditure logic. A sea wall whose primary purpose is coastal-zone protection of property and infrastructure is recorded under transport / coastal protection GFCF. A sea wall whose primary purpose is pollution abatement or habitat protection (e.g., constructed as part of an MPA management programme) is recorded under environmental protection.
- ¶3 **The same expenditure must not appear in both the GFCF total and the environmental protection expenditure total** in a single summary table, unless the current and capital components are explicitly separated and labelled. Where EPEA is reported alongside GFCF (as in TG-2.6 Table 3), the EPEA row should be understood as additional to GFCF, covering current expenditure plus any capital expenditure that has been classified under EPEA rather than under sectoral GFCF.
- ¶4 Cross-reference: SEEA Central Framework paragraphs 4.85-4.88 on the definition of total national expenditure on environmental protection, and the broader CEPA 2000 primary-purpose classification principle that underpins EPEA.

3.7 Worked Example: Ocean Economy SUT for Country A

¶1 To illustrate the compilation procedure, this section presents a worked example for a hypothetical medium-income coastal state ('Country A') with a total GDP of approximately USD 50 billion, total employment of 10 million persons, and an ocean economy representing 3.5 per cent of GDP. All monetary values are expressed in millions of USD. The example demonstrates how the ocean economy SUT template (Table 1) is populated with synthetic data consistent with the structural indicators presented in **TG-2.5 Ocean Economy Structure** Section 3.2 (Table 3.1).

DRAFT

Compilation context

¶1 Country A has:

- ¶2 A diversified ocean economy dominated by coastal tourism (32% of ocean GVA) and offshore oil and gas (24%)
- ¶3 Maritime transport and port operations contributing 18% of ocean GVA
- ¶4 A traditional marine living resources sector (fishing, aquaculture, fish processing) contributing 10%
- ¶5 Emerging marine renewable energy sector (offshore wind) contributing 4%
- ¶6 Shipbuilding and 'other ocean industries' (marine research, maritime education, coast guard) making up the remainder

¶7 The compilation follows the seven-step procedure in Section 3.5, extracting ocean industry columns from national SUTs and applying ocean economy ratios to partially ocean-related industries.

Simplified ocean economy supply table (Country A)

¶1 Table 3 presents a simplified supply table for eight ocean-characteristic product groups and seven ocean industry groups. The table records domestic production by industry (columns 2–8), imports (column 9), and total supply (column 10).

¶2 **Table 3: Ocean Economy Supply Table, Country A (million USD, basic prices)**

Product	Fishing/Aqua	Fish Processing	Shipping/Ports	Offshore Energy	Shipbuilding	Tourism	Other	Imports	To Su
Fish products	180	–	–	–	–	–	–	35	21
Processed fish	–	135	–	–	–	–	–	5	14
Transport services	–	–	565	–	–	–	–	55	62
Port services	–	–	65	–	–	–	–	–	65
Energy products	–	–	–	840	–	–	–	93	93
Ships/vessels	–	–	–	–	280	–	–	28	30
Tourism services	–	–	–	–	–	875	–	58	93
Other ocean products	15	10	–	–	28	58	174	60	34
Non-ocean products (memo)	–	–	–	–	–	–	–	–	1,

Product	Fishing/Aqua	Fish Processing	Shipping/Ports	Offshore Energy	Shipbuilding	Tourism	Other	Imports	To Su
Total output	**195**	**145**	**630**	**840**	**308**	**933**	**174**	**334**	**To su pl 3,**

¶3 The industry column totals show gross output for each ocean industry. The rightmost figure (3,559) is total supply of the eight ocean-characteristic product groups: domestic output of 3,225 plus imports of 334. It must equal total use of those same products in the balanced SUT.

¶4 Ocean industries also buy inputs that are not ocean-characteristic products — fuel bought ashore, insurance, professional services, construction materials. Those products are supplied by non-ocean industries and lie outside the extracted sub-matrix, so they are carried as a single memorandum row rather than being attributed to an ocean industry column. Recording them inside an ocean product row is a common compilation error: it inflates that product's use above its supply and breaks the balance for the row.

Simplified ocean economy use table (Country A)

¶1 Table 4 presents the use table showing intermediate consumption by industry (columns 2–8), final demand categories (columns 9–12), and total use (column 13). The bottom rows show total intermediate consumption, GVA, and total output (which must equal the output row from the Supply Table).

¶2 **Table 4: Ocean Economy Use Table, Country A (million USD, basic prices)**

Product	Fishing/Aqua	Fish Processing	Shipping/Ports	Offshore Energy	Shipbuilding	Tourism	Other	Households
Fish products	5	120	–	–	–	–	–	50
Processed fish	–	–	–	–	–	5	–	55
Transport services	5	5	50	20	10	30	5	50
Port services	–	–	3	2	5	–	–	5
Energy products	2	3	100	84	20	80	14	300
Ships/vessels	–	–	–	–	3	–	–	–
Tourism services	–	–	5	–	–	47	5	820
Other ocean products	8	7	40	30	25	50	15	25
Non-ocean products (memo)	–	–	117	284	122	161	48	40
Total intermed.	**20**	**135**	**315**	**420**	**185**	**373**	**87**	**–**
GVA	**175**	**10**	**315**	**420**	**123**	**560**	**87**	**–**
Total output	**195**	**145**	**630**	**840**	**308**	**933**	**174**	
Total final demand								**1,345**

DRAFT

¶3 Note: The table is balanced. Every product row satisfies total supply (Table 3) = total use, every industry column satisfies output = intermediate consumption + GVA, and the industry Total Output row (USD 3,225M) equals the corresponding totals in Table 3. Total intermediate consumption is USD 1,535M and GVA is USD 1,690M (= 3,225 - 1,535). The non-ocean products row is the memorandum row introduced in Table 3: it carries the inputs ocean industries buy from outside the ocean economy, and it is excluded from every ocean economy aggregate below.

Key aggregates derived from the SUT

¶1 From Tables 3 and 4, the following ocean economy aggregates are derived. Table 3.6.1 below summarises the key aggregates.

Aggregate	Value	Derivation from Tables 3 and 4
Ocean economy output	USD 3,225M	Sum of the industry Total Output row, Table 3
Ocean economy intermediate consumption	USD 1,535M	Sum of the Total intermed. row, Table 4
Ocean economy GVA	USD 1,690M	3,225 - 1,535; equals the sum of the GVA row, Table 4
Ocean economy exports	USD 1,205M	Exports column, Table 4 (1,212) less the non-ocean memorandum row (7)
Ocean economy GFCF	USD 195M	GFCF column, Table 4 (380) less the non-ocean memorandum row (185)
Ocean economy imports	USD 334M	Sum of the Imports column, Table 3

¶2 Every figure above is derivable from the two tables and from nothing else. That is the property to preserve when a compiler substitutes national data: an aggregate that cannot be recomputed from the published tables cannot be audited.

¶3 **Reconciliation with TG-2.5. TG-2.5 Ocean Economy Structure** Tables 3.1 and 3.1a report the same illustrative Country A on a fuller compilation that includes minor ocean industries omitted from this simplified SUT. The two presentations must be reconciled before either is cited, not used interchangeably.

Aggregate	This SUT	TG-2.5	Difference	Status
Output	3,225	3,436	+211	Reconciled: minor ocean industries outside the seven industry groups shown here

Aggregate	This SUT	TG-2.5	Difference	Status
GVA	1,690	1,750	+60	Reconciled: same minor industries
Exports	1,205	620	-585	**Not reconciled.** The difference is larger than the industry coverage gap and runs in the opposite direction. Compilers should not cite either figure until the Secretariat resolves which product scope TG-2.5 Table 3.1a applies to exports.

¶4 Where the reconciliation holds, the aggregates feed the structural indicators in TG-2.5: ocean economy share of GDP (1,750/50,000 = 3.5%) and ocean economy investment rate (195/1,750 = 11.1%). The share-of-exports indicator is held back pending the reconciliation above.

Cross-stack linkages

¶1 The ocean economy SUT compiled in this example provides the 'data foundation' for multiple downstream applications across the Ocean Accounts Technical Guidance series:

- ¶2 **Upward to indicators:** The GVA, employment, and trade aggregates derived from the SUT populate the structural indicators in **TG-2.5** Tables 3.1, 3.1a, 3.1b, and 3.3.
- ¶3 **Upward to budget processes:** The four-row budget presentation format in **TG-1.1** Section 3.3 draws GDP contribution, employment, and export values directly from the SUT aggregates.
- ¶4 **Upward to investment analysis:** The GFCF column in the Use Table (Table 4) provides the industry-level investment data required for the investment indicators in **TG-2.6**.
- ¶5 **Downward to data sources:** The product and industry detail required to populate the SUT draws on survey data (**TG-4.2**) and administrative records (**TG-4.3**), harmonised through the procedures in **TG-4.6**.
- ¶6 **Lateral to flows accounting:** The production data by ocean industry (output and intermediate consumption) feed into the economy-to-environment flow accounts in **TG-3.4**, enabling estimation of marine pollution, resource extraction, and other pressures.
- ¶7 **Lateral to combined presentations:** The aggregates derived from the ocean economy SUT are integrated with ecosystem accounts in the combined presentation structures described in **TG-3.8**.

3.8 Treatment of Coastal Tourism

¶1 Coastal tourism presents particular challenges for supply and use table compilation because tourism is defined from the demand side (activities of visitors) rather than the supply side (industrial classification)[34]. The Statistical Framework for Measuring the Sustainability of Tourism (SF-MST) provides guidance on integrating tourism statistics with economic and environmental accounts[35].

¶2 For ocean economy accounts, the recommended approach is set out in Table 3.7.1 below.

DRAFT

Step	Description
1. Identify coastal tourism destinations	Delineate coastal areas where tourism activity is concentrated.
2. Estimate coastal tourism expenditure	Using visitor surveys or tourism satellite account data, estimate tourism expenditure in coastal destinations.
3. Allocate expenditure to products	Classify tourism expenditure by product category (accommodation, food, transport, recreation).
4. Estimate ocean-related shares	Within coastal tourism expenditure, estimate the share directly attributable to marine activities (such as marine recreation, diving, fishing charters) versus general tourism services.
5. Integrate with SUTs	Incorporate coastal tourism product flows into the supply and use table framework, ensuring consistency with TSA methodology where available.

¶3 The SF-MST provides specific guidance on measuring tourism at sub-national levels, including destination-level measurement approaches that are directly applicable to coastal and marine tourism areas[36].

3.9 Integration with National SUTs

¶1 Ocean economy SUTs should be compiled as a disaggregation of national SUTs, ensuring that:

- ¶2 Ocean industry output and intermediate consumption aggregate to values consistent with national accounts
- ¶3 Ocean product supplies and uses aggregate to values consistent with national commodity flow accounts
- ¶4 Ocean economy GVA sums to a component of national GDP

¶5 This integration ensures that ocean economy statistics are consistent with and comparable to national economic statistics, and enables analysis of the ocean economy's share of national aggregates.

3.10 Extended Applications: Input-Output Analysis

¶1 Balanced supply and use tables provide the foundation for constructing symmetric **input-output tables** (IOTs) that enable extended analytical applications[37]. Input-output analysis allows estimation of:

- ¶2 **Multiplier effects** – the total economic impact of ocean industries, including direct, indirect, and induced effects throughout the economy
- ¶3 **Backward and forward linkages** – the degree to which ocean industries are integrated with other sectors of the economy

- ¶4 **Embodied resource flows** – the natural inputs (including marine resources) embodied in production throughout supply chains

¶5 These extended analyses support policy assessment and are relevant to the derivation of economic dependency indicators described in **TG-2.2 Macro-level Dependencies**.

Implementation Considerations

¶1 For minimum institutional capacity, data infrastructure, and human skills requirements for compiling these accounts, see TG-0.8 Implementation Readiness Assessment. For guidance on adapting these methods to sub-national scales, see TG-3.11 Sub-National Ocean Accounts.

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

5. References

1. ¶1 OECD (2016). *The Ocean Economy in 2030*. Paris: OECD Publishing. The OECD definition encompasses "ocean-based industries" and "natural assets and ecosystem services that the ocean provides."
2. ¶2 United Nations (2024). *SEEA Ecosystem Accounting*, para 13.88. The ocean economy is measured "in terms of the contribution of the main ocean-related activities…to the national economy."
3. ¶3 World Tourism Organization (2024). *SF-MST*, paras 2.31–2.35 set out a qualitative significance criterion for identifying tourism characteristic activities ("a significant share" of expenditure or supply) but do not specify a numeric threshold; SF-MST expressly treats the setting of such thresholds as outside the statistical task (para 2.5). The 5 per cent figure is therefore a pragmatic materiality threshold adopted by this guidance to operationalise that significance principle for the ocean economy context, not a value drawn from SF-MST.
4. ¶4 This categorisation draws on OECD (2016). *The Ocean Economy in 2030*. Paris: OECD Publishing. Categories 5–7 extend the direct activity boundary to incorporate ecosystem values and macroeconomic linkages.
5. ¶5 United Nations et al. (2025). *System of National Accounts 2025*, Chapter 38, para 38.2. See also para 38.6 on the distinction between thematic accounts (disaggregating within SNA boundaries) and extended accounts (expanding SNA boundaries).
6. ¶6 United Nations et al. (2025). *System of National Accounts 2025*, para 35.63 on ocean accounting applications, and para A1.135 on SEEA Ecosystem Accounting thematic accounts for oceans.
7. ¶7 United Nations (1982). *United Nations Convention on the Law of the Sea*. Part V on Exclusive Economic Zone establishes coastal state rights to resources within 200 nautical miles.
8. ¶8 United Nations et al. (2025). *System of National Accounts 2025*, Annex 5, paras A5.30–A5.43 on Accounting for the economic activities of non-resident units making use of quota established for fishing in a country's Exclusive Economic Zone.
9. ¶9 United Nations (2023). *Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction* (BBNJ Agreement). Entered into force 17 January 2026.
0. ¶10 Colgan, C.S. (2022). *A Guide to Creating Core Ocean GDP Accounts*. Global Ocean Accounts Partnership. Available at: https://www.oceanaccounts.org/a-guide-to-creating-core-ocean-gdp-accounts/ (https://www.oceanaccounts.org/a-guide-to-creating-core-ocean-gdp-accounts/)
1. ¶11 United Nations (2024). *SEEA Ecosystem Accounting*, para 2.24. Ecosystem services are "the contributions of ecosystems to the benefits that are used in economic and other human activity."
2. ¶12 United Nations et al. (2025). *System of National Accounts 2025*, Chapter 38, para 38.2. The SNA 2025 uses the term "thematic and extended accounts" in place of the former "satellite accounts" terminology used in earlier editions.
3. ¶13 United Nations, UNWTO, Eurostat, and OECD (2010). *Tourism Satellite Account: Recommended Methodological Framework 2008*. The TSA provides the methodological template for sector-specific thematic accounts.
4. ¶14 World Tourism Organization (2024). *SF-MST*, paras 2.33–2.35 on tourism characteristic products and tourism characteristic activities. The framework defines tourism characteristic products as "consumption products that satisfy one or both of the following criteria: (i) tourism expenditure on the product should represent a significant share of total tourism expenditure; (ii) tourism expenditure on the product should represent a significant share of the supply of the product in the economy" (para 2.33).
5. ¶15 United Nations et al. (2025). *System of National Accounts 2025*, Chapter 38, paras 38.6–38.14 describe the principles of thematic and extended accounts.
6. ¶16 This structure adapts the TSA framework (TSA:RMF 2008) to ocean economy measurement. See also NOEA (National Ocean Economics Program) methodology used in the United States.
7. ¶17 UNWTO and UNSD (2008). *International Recommendations for Tourism Statistics 2008*. Chapter 7 provides detailed guidance on employment measurement in tourism industries, applicable by extension to ocean economy employment accounts.
8. ¶18 United Nations (2008). *International Standard Industrial Classification of All Economic Activities (ISIC), Revision 4*. Statistical Papers Series M No. 4/Rev.4. New York: United Nations.
9. ¶19 United Nations (2024). *ISIC Rev.5 - Rev.4 Correspondence Tables*. UNSD Classifications Registry. Compilers should consult the latest correspondence tables available from the UN Statistics Division.
0. ¶20 ISIC Rev.4 detailed structure and explanatory notes. Division 03 (Fishing and aquaculture) and Division 50 (Water transport) represent core ocean industries.
1. ¶21 The identification of ocean-related industries follows approaches used in the EU Blue Economy Report (European Commission, annual) and US National Ocean Economics Program.
2. ¶22 World Tourism Organization (2024). *SF-MST*, paras 4.50–4.53 on tourism ratios. The tourism ratio is "the total output of tourism characteristic products by an industry divided by its total output" (para 4.50).
3. ¶23 Methods for estimating industry shares follow general SNA guidance on compiling thematic and extended accounts (SNA 2025 Chapter 38) and specific guidance in TSA:RMF 2008.
4. ¶24 UNWTO (2010). *Tourism Satellite Account: Recommended Methodological Framework 2008*, paras 4.50–4.53 on tourism ratios.
5. ¶25 World Tourism Organization (2024). *SF-MST*, para 3.28 on the tourism ratio.
6. ¶26 United Nations et al. (2025). *System of National Accounts 2025*, Chapter 15 describes supply and use tables in detail. Para 15.9 introduces the basic structure: "Supply tables show how products are made available to the economy, from domestic industries and through imports. Use tables show how these products are consumed, as intermediate consumption by industries or as final consumption, capital formation or exports."
7. ¶27 World Tourism Organization (2024). *SF-MST*, Chapter 3 on Measuring the economic dimension, particularly Section 3.3 on Measuring the economic structure and performance of tourism industries.
8. ¶28 World Tourism Organization (2024). *SF-MST*, para 2.31 on tourism characteristic activities.

DRAFT

9. ¶29 United Nations et al. (2025). *System of National Accounts 2025*, Chapter 38, paras 38.20–38.30 on the use of supply and use tables in thematic and extended accounts. The template adapts the general SUT framework to ocean economy measurement.
0. ¶30 Based on ISIC Rev.4 detailed structure (United Nations, 2008) and ocean economy industry identification approaches used in OECD (2016) and the EU Blue Economy Report (European Commission, annual).
1. ¶31 SNA 2025, Chapter 11 on the capital account (economic ownership) and Chapter 35 on measuring the sustainability of well-being, including discussion of natural resources and areas beyond national jurisdiction. For the corresponding external sector treatment see BPM7 Chapter 4, paras 4.214–4.220.
2. ¶32 SNA 2025, paragraph 35.129.
3. ¶33 United Nations (2023). *Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction* (BBNJ Agreement). Entered into force 17 January 2026.
4. ¶34 UNWTO and UNSD (2008). *International Recommendations for Tourism Statistics 2008*. Tourism is defined from the visitor (demand) perspective.
5. ¶35 UNWTO (2024). *Statistical Framework for Measuring the Sustainability of Tourism (SF-MST)*. Final Draft, February 2024. Chapters 2–3 address economic dimension measurement.
6. ¶36 UNWTO (2024). *SF-MST*, Section 2.5 on Measuring the sustainability of tourism at sub-national levels, and Section 3.7 on Measuring the economic dimension for sub-national spatial areas.
7. ¶37 Eurostat (2008). *Eurostat Manual of Supply, Use and Input-Output Tables*. Chapter 11 addresses transformation of SUTs to symmetric input-output tables.

DRAFT

Flows from Economy to Environment

Provides guidance on compiling accounts for flows from the economy to the marine and coastal environment.

Version 0.9.2 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

OUTCOME

This Circular provides guidance on compiling accounts for flows from the economy to the marine and coastal environment, encompassing pollution, residuals, and physical pressures. Upon completing this Circular, readers will understand:

- Why tracking economy-to-environment flows matters for ocean policy and management
- How to compile physical flow accounts for emissions, waste, and residuals that reach marine waters, and the residual categories relevant to marine and coastal assessment (Section 3.2)
- How terrestrial pressures are attributed across the land-sea interface to the coastal units that receive them, using drainage basin allocation (Section 3.5)
- How to attribute land-based pollution to coastal and marine areas using drainage basin allocation
- How to measure physical pressures such as underwater noise and habitat disturbance
- How to link residual flow accounts to pressure indicators and ecosystem condition accounts

The guidance enables compilation of residual flow accounts consistent with the System of Environmental-Economic Accounting Central Framework (SEEA CF). It integrates with the broader Ocean Accounts framework described in TG-0.1 General Introduction. This Circular builds on the physical flow accounting framework established in TG-3.1 Asset Accounts and the economic activity classifications detailed in TG-3.3 Economic Activity Relevant to the Ocean. The accounts compiled using this guidance support derivation of indicators for environmental pressure assessment (TG-2.7 Pollution and Other Flows to Environment) and ecosystem degradation monitoring (TG-2.8 Climate Change Indicators).

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 3
3.0 Decision Use-Case Framing 4
3.1 Conceptual Framework for Residual Flows 4
3.2 Pollution and Emissions 5
3.3 Solid Waste 11
3.4 Compilation Procedure for Physical Flow Accounts 13
3.5 Attribution to Economic Sectors 16
3.6 Physical Pressures 21
3.7 Combined Presentations and Indicators 23
3.8 Cross-Stack Connections 24
3.9 Monetary Valuation of Residual Flows 25
4. Data Sources and Compilation 26
5. Acknowledgements 28
6. References 28

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Flows from Economy to Environment (2026) (GOAP Technical Guidance on Ocean Accounting, TG-3.4, v0.9.2). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-3/3-4-flows-econ-env/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

¶1 **Framework Position**

¶2 TG-3.4 provides the pressure-side complement to TG-3.2 Flows from Environment to Economy, which records the extraction of resources from the ocean. Where TG-3.2 measures what the economy takes from the marine environment, this Circular measures what the economy returns to it — pollution, residuals, and physical disturbances. Together, TG-3.2 and TG-3.4 form the two-directional boundary between economy and environment within the Section 3 physical flow accounts, and their outputs feed directly into the pressure indicators compiled in TG-2.7 Pollution and Other Flows to Environment and TG-2.8 Climate Change Indicators.

¶3 **Scope.** TG-3.4 owns the residual side of the physical supply and use table: the substance rows, the generating-industry columns, the receiving-medium columns, and the supply-equals-use identity for each substance. It cross-refers for substance-specific method to Section 6 — marine litter and plastics to **TG-6.12**, aquaculture effluent to **TG-6.8**, shipping emissions to **TG-6.10** — and for the monitoring and modelling that produce the quantities to Section 4.

1. Outcome

¶1 This Circular provides guidance on compiling accounts for flows from the economy to the marine and coastal environment, encompassing pollution, residuals, and physical pressures. Upon completing this Circular, readers will understand:

- ¶2 Why tracking economy-to-environment flows matters for ocean policy and management
- ¶3 How to compile physical flow accounts for emissions, waste, and residuals that reach marine waters, and the residual categories relevant to marine and coastal assessment (Section 3.2)
- ¶4 How terrestrial pressures are attributed across the land-sea interface to the coastal units that receive them, using drainage basin allocation (Section 3.5)
- ¶5 How to attribute land-based pollution to coastal and marine areas using drainage basin allocation
- ¶6 How to measure physical pressures such as underwater noise and habitat disturbance
- ¶7 How to link residual flow accounts to pressure indicators and ecosystem condition accounts

¶8 The guidance enables compilation of residual flow accounts consistent with the System of Environmental-Economic Accounting Central Framework (SEEA CF)[1]. It integrates with the broader Ocean Accounts framework described in TG-0.1 General Introduction. This Circular builds on the physical flow accounting framework established in TG-3.1 Asset Accounts and the economic activity classifications detailed in TG-3.3 Economic Activity Relevant to the Ocean. The accounts compiled using this guidance support derivation of indicators for environmental pressure assessment (TG-2.7 Pollution and Other Flows to Environment) and ecosystem degradation monitoring (TG-2.8 Climate Change Indicators).

DRAFT

2. Requirements

¶1 This Circular requires familiarity with:

- ¶2 **TG-0.1 General Introduction to Ocean Accounts** — for the conceptual framework and key components of Ocean Accounts
- ¶3 **TG-3.1 Asset Accounts** — for the general framework of physical supply and use tables and residual flow accounting
- ¶4 **TG-3.3 Economic Activity Relevant to the Ocean** — for industry classifications and economic sector definitions relevant to ocean accounting

3. Guidance Material

3.0 Decision Use-Case Framing

¶1 Residual flows from the economy to the marine environment are pressures that affect ecosystem health, fisheries productivity, coastal protection capacity, and human well-being. Policy-makers require systematic information on these flows to answer questions such as:

- ¶2 Which economic sectors contribute most to nutrient loading in coastal waters, and how can agricultural and aquaculture practices be adjusted to reduce eutrophication?
- ¶3 What is the trajectory of plastic waste reaching the ocean from land-based sources, and are waste management interventions reducing marine litter?
- ¶4 How do ship emissions contribute to ocean acidification and coastal air quality, and what would be the impact of stricter fuel standards?
- ¶5 Which coastal areas face the greatest pollution pressure from multiple sources, and where should marine spatial planning prioritise environmental protection?

¶6 Ocean accounts for residual flows provide an empirical foundation for addressing these questions. Organising data on emissions, waste, and physical disturbances within a coherent accounting framework allows compilers to track pressures over time, attribute them consistently to economic sources, and integrate them with ecosystem condition accounts to assess environmental outcomes. These accounts support evidence-based policy design, monitoring of international commitments (including SDG Target 14.1 on marine pollution), and evaluation of intervention effectiveness.

3.1 Conceptual Framework for Residual Flows

¶1 The marine environment receives substantial flows of residuals from economic activity, including pollutants discharged to water, solid waste and marine litter, atmospheric emissions that deposit in ocean waters, and physical disturbances such as underwater noise and light pollution. These flows constitute pressures on marine ecosystems that can affect ecosystem condition and the capacity of marine ecosystems to deliver services. Accounting for these flows enables assessment of the environmental impact of economic activity and supports policy responses aimed at reducing pressures on the marine environment.

DRAFT

¶2 The accounting framework for residual flows draws on the physical supply and use table (PSUT) structure established in the SEEA Central Framework[2]. Residuals are defined as flows of solid, liquid, and gaseous materials, and energy, that are discarded, discharged, or emitted by establishments and households through processes of production, consumption, or accumulation[3]. For ocean accounting purposes, the focus is on residual flows that reach marine and coastal waters either directly or through intermediary pathways.

¶3 Residual flows correspond to the 'Pressures' component in the widely used Drivers-Pressures-State-Impact-Response (DPSIR) framework for environmental assessment. Economic activities (Drivers) generate residual flows (Pressures) that affect marine ecosystem condition (State), resulting in consequences for ecosystem services and human welfare (Impact), which in turn prompt policy actions (Response). The accounting framework presented in this Circular provides a systematic, quantitative basis for measuring the Pressures component and linking it to the economic Drivers through industry attribution. Figure 3.4.1 sets the DPSIR concept alongside the physical supply-use table that records these flows. Each substance is routed in that table to its receiving destination.

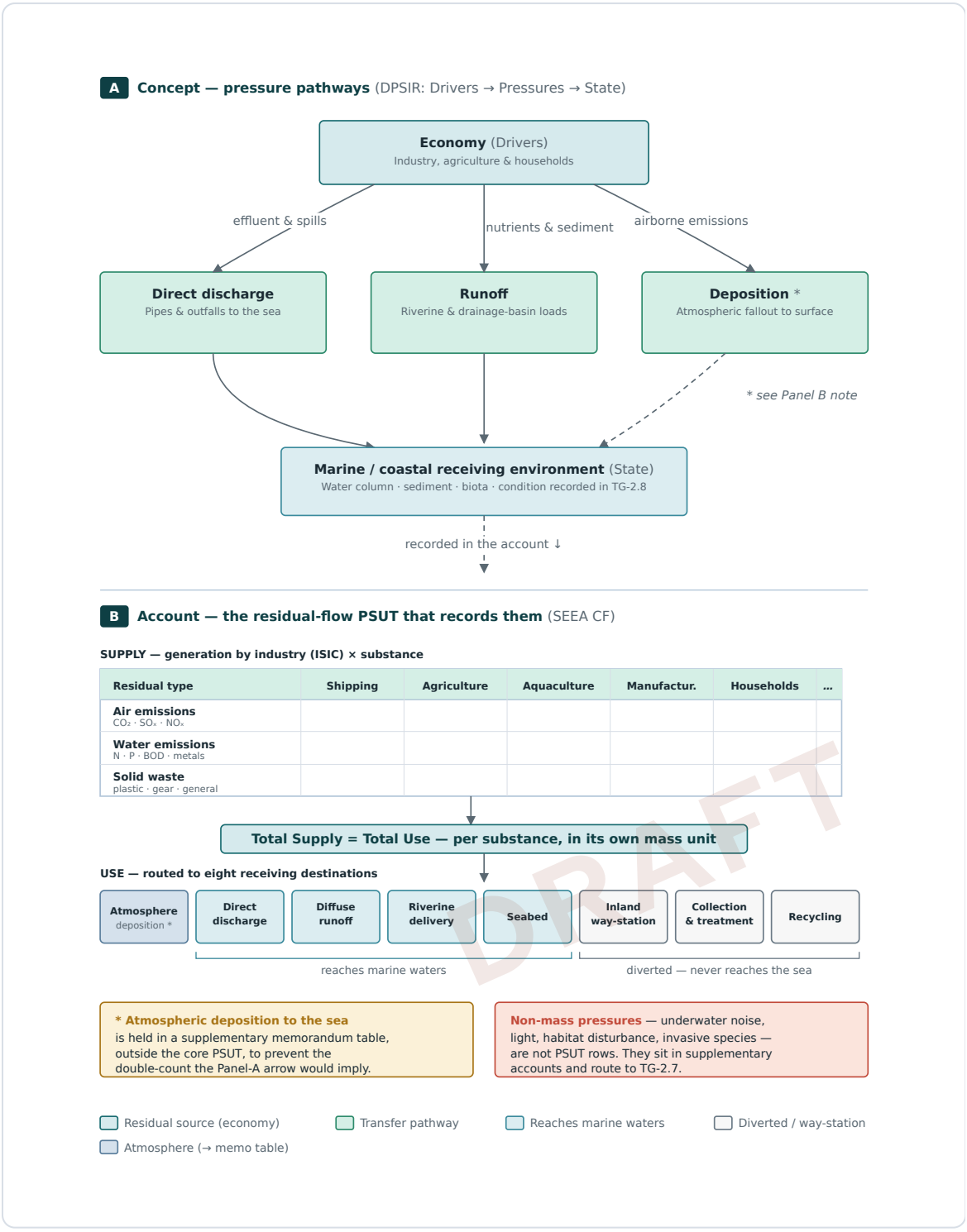


Figure 3.4.1 Residual pollution is shown as concept pathways (Panel A) and as the balancing physical supply-use table that records them (Panel B). Diverted destinations must stay on the use side to keep supply = use; atmosphere and non-mass pressures use memorandum or supplementary accounts.

Source: TG-3.4 draft §3.4 (Table 1 residual-flow PSUT template), §3.5 (attribution to industries; drainage-basin allocation), §3.6 (physical pressures); residual-flow recording per SEEA CF. Complements the carbon-cycle figure (fig-tg-3-4-carbon-cycle), which depicts the atmospheric pathway in isolation.

3.2 Pollution and Emissions

¶1 Marine pollution encompasses substances released to water resources and the atmosphere that subsequently affect ocean waters. The SEEA framework distinguishes between emissions

to air, emissions to water, and emissions to soil, each of which can contribute to marine environmental degradation [4].

3.2.1 Emissions to water

¶1 Emissions to water are substances released to water resources by establishments and households as a result of production, consumption, and accumulation processes [5]. These emissions can reach marine waters through several pathways, summarised in Table 3.2.1 below.

Pathway	Description
Direct discharges	Substances released directly to marine or coastal waters from industrial facilities, vessels, or coastal infrastructure.
Indirect discharges via sewerage	Substances released to sewerage systems that subsequently discharge to marine waters, either treated or untreated.
Non-point source emissions	Diffuse releases including urban runoff, agricultural runoff carrying fertilisers and pesticides, and leaching from contaminated sites.

¶2 The SEEA water emissions account records the quantity of substances added to water by establishments and households during an accounting period, expressed in mass units (kilograms or tonnes depending on the substance) [6]. Table 3.2.1 below summarises key substance categories for marine water quality.

Category	Description
Nutrients	Nitrogen and phosphorus compounds that contribute to eutrophication; SDG indicator 14.1.1 specifically addresses coastal eutrophication through an index that includes nutrient loading [7] ; agricultural activities are a primary source, particularly through application of fertilisers and management of livestock manure, as documented in the SEEA Agriculture, Forestry and Fisheries (SEEA AFF) guidance on nutrient flow accounts [8] .
Organic matter	Measured through biological oxygen demand (BOD) and chemical oxygen demand (COD), indicating substances that affect oxygen balance in receiving waters.
Heavy metals	Including mercury, cadmium, lead, and other metals that accumulate in marine food chains.
Persistent organic pollutants	Chemicals that resist degradation and bioaccumulate, including legacy pollutants such as PCBs and contemporary substances of concern.
Oil and petroleum products	From operational discharges, spills, and urban runoff.
Pharmaceuticals and personal care products	Emerging contaminants of increasing concern for marine ecosystems.

¶3 Microplastics are particles less than 5mm, either fragmented from larger items or manufactured as primary microplastics (e.g., microbeads, pellets). They represent a growing concern for marine ecosystems [9]. For accounting classification, compilers should apply the following decision tree:

- ¶4 **(a) Primary microplastics** (manufactured as such, e.g., industrial pellets, cosmetic microbeads) — record as solid waste attributed to the generating industry at the point of generation. These do not appear as water emissions.
- ¶5 **(b) Secondary microplastics** (formed by in-environment fragmentation of larger plastic items) — these are out of scope for the generating-industry supply side of the account. Record them only in a supplementary note to the account. The originating plastic items will already appear as solid waste under the appropriate industry.
- ¶6 **(c) Microplastics in treated or untreated wastewater effluent** — record as water emissions attributed to the sewerage industry (ISIC 37), not to the originating consumer industry. This

DRAFT

follows the SEEA CF principle that residuals generated through treatment or intermediary processing are attributed to the unit carrying out that activity[3].

¶7 Applying this decision tree consistently prevents double-counting between the solid waste and water emissions rows of the account. Compilers should document the classification approach adopted in account metadata, as required by SEEA CF paragraphs 3.73-3.87.

¶8 For ocean accounting, the water emissions account should be extended to distinguish between:

- ¶9 Emissions to inland water resources that subsequently flow to marine waters
- ¶10 Emissions directly to coastal and marine waters
- ¶11 Emissions collected by sewerage systems with discharge to marine waters

¶12 The SEEA Technical Note on Water Accounting provides detailed guidance on the structure of water emission accounts, including treatment of point and non-point sources[10].

3.2.2 Atmospheric emissions affecting marine waters

¶1 Certain atmospheric emissions ultimately deposit in ocean waters and contribute to marine environmental change. Air emissions accounts record gaseous and particulate substances released to the atmosphere by establishments and households[11]. Substances of particular relevance for marine impacts include:

- ¶2 **Carbon dioxide (CO2)** – contributing to ocean acidification through absorption of atmospheric CO2 by ocean surface waters. Ocean acidification affects calcifying organisms including corals, molluscs, and some plankton species, with implications for marine food webs and fisheries productivity
- ¶3 **Nitrogen compounds (NOx, NH3)** – contributing to atmospheric deposition of nitrogen to marine waters, supplementing waterborne nutrient loading
- ¶4 **Sulphur compounds (SOx)** – contributing to atmospheric deposition and affecting marine chemistry
- ¶5 **Mercury and other metals** – depositing through wet and dry atmospheric deposition, entering marine food chains

DRAFT

¶6 The accounting challenge is to link atmospheric emissions to their marine deposition, which requires integration with atmospheric modelling or use of deposition coefficients. The SEEA CF notes that such atmospheric transfers occur within the environment and are generally not recorded in the air emissions account. Whilst that convention governs the core account, the atmospheric pathway from economic activity to marine impact may warrant supplementary recording for ocean accounting purposes[12].

¶7 **Supplementary memorandum table for atmospheric deposition to marine waters**

¶8 To provide compilers with a mechanism for recording the atmospheric deposition pathway without creating double counting in the core PSUT, a supplementary memorandum table may be compiled alongside the core account. This table is explicitly outside the SEEA CF core account structure and must not be added to or substituted for Table 1. Its purpose is to support policy analysis linking economic air emission sources to marine nitrogen and sulphur deposition.

¶9 *Table M1: Supplementary Memorandum Table – Estimated Atmospheric Deposition to Marine Waters (outside SEEA CF core account)*

Substance	Source industry (supply from core air emissions account)	Estimated deposition to EEZ/marine area (tonnes/year)	Data source for deposition estimate
Nitrogen (NOx as N)	Shipping (ISIC 50), Agriculture (ISIC 01), Energy (ISIC 35)	[estimate]	EMEP regional deposition model; national deposition monitoring

Substance	Source industry (supply from core air emissions account)	Estimated deposition to EEZ/marine area (tonnes/year)	Data source for deposition estimate
Sulphur (SOx as S)	Shipping (ISIC 50), Energy (ISIC 35)	[estimate]	EMEP regional deposition model
Mercury	Energy (ISIC 35), Manufacturing (ISIC 24)	[estimate]	AMAP/UNEP global atmospheric mercury deposition model

¶10 The upstream (economic) side of this table draws directly on the core air emissions account totals for the relevant industries and substances. The deposition estimates are derived from atmospheric modelling or regional datasets. For European countries, the EMEP model provides substance-specific wet and dry deposition to sea areas [12] . The table should carry a clear label distinguishing it from the core PSUT so that users do not interpret the deposition column as a separate use-side entry that would generate double counting with the "Atmosphere" use column in Table 1.

¶11 Ocean acidification (the decrease in ocean pH resulting from absorption of atmospheric CO2) is a major indirect pathway from economic residual flows to marine environmental change. The ocean absorbs approximately 25-30% of anthropogenic CO2 emissions, with measurable effects on marine chemistry. SDG indicator 14.3.1 tracks ocean acidification using mean marine acidity (pH) measurements. For ocean accounts, the air emissions account provides the upstream measure (CO2 generated by economic activity), whilst the ecosystem condition account records the downstream effect (changes in ocean pH).

¶12 The carbon cycle describes how carbon flows between the atmosphere, biosphere, oceans, geosphere, and the economy. Tracing the full pathway from economic emissions to marine environmental impact depends on this cycle. Figure 3.4.2 presents the main components of the carbon cycle as described in SEEA EA [13] , [14] .

DRAFT

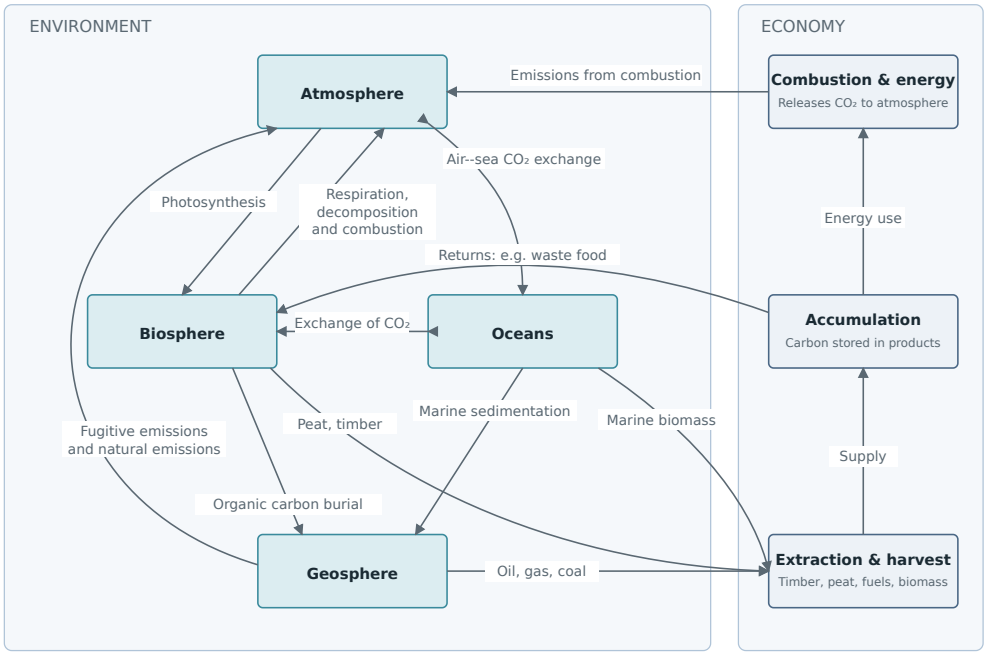


Figure 3.4.2 Global carbon stocks in atmosphere, biosphere, oceans and geosphere exchange with the economy through extraction, use and emissions. Air--sea CO_2 exchange is the dominant ocean carbon flux for ocean accounting.

Source: SEEA EA 2024, Figure 13.1; air--sea CO_2 exchange and ocean carbon flows after IPCC AR6 WG1 Chapter 5.

Adapted from: SEEA EA 2024, Figure 13.1 -- redrawn in the GOAP palette with the economy disaggregated into extraction, accumulation and combustion activities, and ocean carbon flows (air--sea exchange, marine sedimentation, marine biomass extraction) made explicit for ocean-accounting relevance.

DRAFT

¶13 For ocean accounting, the key pathways include: emissions from combustion of fossil fuels (geosphere → economy → atmosphere), ocean uptake of atmospheric CO2 (atmosphere → oceans), and sequestration by coastal ecosystems such as mangroves and seagrasses (atmosphere → biosphere). The residual flow accounts described in this Circular capture the economy-to-atmosphere pathway, whilst the ecosystem service accounts in TG-3.2 Flows from Environment to Economy capture the ocean and biosphere absorption pathways.

3.2.3 Marine-specific pollution sources

¶1 Certain pollution sources are specific to marine environments:

- ¶2 **Vessel emissions** – discharges from ships including bilge water, ballast water (with associated invasive species risk), sewage, and cargo residues. The International Maritime Organization's MARPOL Convention provides regulatory framework for these discharges[15]. Ballast water management is also addressed under the IMO Ballast Water Management Convention (2004, entered into force 2017)
- ¶3 **Offshore operational discharges** – produced water from oil and gas extraction, drilling fluids, and platform discharges. Guidance on offshore energy accounting is provided in TG-3.10 Offshore Energy
- ¶4 **Aquaculture effluent** – nutrient-rich discharges, pharmaceutical residues, and organic matter from marine aquaculture operations. These flows should be recorded as part of aquaculture industry emissions (ISIC 0321)

- ¶5 **Port operations** – dredging spoils, stormwater runoff, and operational discharges from port facilities

¶6 **Ballast water: supplementary physical account**

¶7 Ballast water discharge can be recorded in a supplementary physical account, distinct from the core material flow account, using the following data elements:

- ¶8 **(a) Volume of ballast water discharged** in national waters (cubic metres per year), sourced from IMO port state control records or vessel self-reporting under the Ballast Water Management Convention
- ¶9 **(b) Origin port classification** – categorising ballast water by the region of intake provides a proxy indicator of the probability of non-native species introduction. Ports in different biogeographic regions carry different species assemblages, and this classification supports risk-tiered monitoring
- ¶10 **(c) BWM Convention compliance status** – expressed as the percentage of vessels discharging in national waters that meet the D-2 biological treatment standard under the IMO Ballast Water Management Convention (2004, in force 2017)

¶11 Invasive species introduced via ballast water are a categorical pressure indicator rather than a mass-flow residual and cannot be recorded within the standard PSUT rows. This pressure is flagged for treatment in TG-2.7 Pollution and Other Flows to Environment. Compilers constructing the ballast water supplementary account should draw on port state control authority records and flag the account clearly as supplementary to, and not included in, Table 1 totals [16].

Residual categories for marine and coastal receiving environments

¶1 *Table 3.2.9: Residual flow categories relevant to marine and coastal assessment*

Residual Category	Examples	EIA Relevance	Measurement Units
Emissions to water	Nutrients (N, P), heavy metals, POPs, thermal effluents, sediment	Direct marine water quality impacts	kg/year, mg/L concentration
Emissions to air	GHGs, particulates, NOx	Ocean acidification, climate effects	tonnes CO2e/year
Solid waste	Marine debris, construction waste, dredge spoil	Benthic habitat impacts, debris accumulation	tonnes/year
Natural resource residuals	Bycatch discards, processing waste	Ecosystem function, nutrient cycling	tonnes/year

DRAFT

¶2 The physical supply and use table organises these flows, recording which industries generate which residuals and distinguishing residuals collected or treated from those discharged directly. Four uses follow, and they are what project-level and cumulative assessment draw on (**TG-1.6 OA and Environmental Impact Assessment** Section 3.4):

¶3 **Source attribution**: Identifying which economic activities contribute which residual flows to marine receiving environments. For example, physical flow accounts might record that aquaculture contributes the largest share of nitrogen loading to a coastal embayment (hypothetically 45%), followed by land-based agriculture (35%) and urban wastewater (20%), providing context for assessing a proposed expansion of aquaculture operations.

¶4 **Load estimation**: Quantifying total residual flows entering marine ecosystems from multiple sources. Accounts compiled at regional scale provide baseline pollution loading against which project incremental loads can be compared.

¶5 **Pathway tracing**: Following residual flows from generation through collection, treatment, and ultimate discharge. Such tracing establishes whether proposed treatment measures are adequate

to prevent unacceptable impacts.

¶6 **Impact linkage**: Connecting residual flow accounts to ecosystem condition accounts to assess how pollution loads affect ecosystem state. Where condition accounts record declining dissolved oxygen in a coastal zone whilst physical flow accounts record increasing nutrient loads, the pairing establishes an empirical pressure-state relationship that can inform EIA predictions for projects that would add nutrient loads.

3.3 Solid Waste

¶1 Solid waste accounts organise information on the generation of solid waste and the management of flows to recycling facilities, controlled landfills, or the environment[17]. For ocean accounting, the principal concern is marine litter — solid waste that enters the marine environment.

3.3.1 Marine litter and plastics

¶1 Marine litter comprises manufactured or processed solid material that enters the marine environment from any source[18]. SDG Target 14.1 calls for prevention and significant reduction of marine pollution of all kinds, including marine debris, with indicator 14.1.1 including floating plastic debris density[19].

¶2 Plastic pollution is the dominant component of marine litter by item count and is of particular concern due to:

- ¶3 Persistence in the marine environment over decades to centuries
- ¶4 Fragmentation into microplastics (particles less than 5mm) that enter marine food webs
- ¶5 Accumulation in ocean gyres, coastal areas, and deep-sea sediments
- ¶6 Harm to marine fauna through ingestion and entanglement

¶7 The TNFD disclosure framework identifies plastic pollution as a specific metric for nature-related disclosure, including plastic footprint measured as total weight of plastics used or sold, disaggregated by reusable, compostable, and technically recyclable categories[20].

¶8 The international framework for plastic pollution management is evolving. The UN Environment Assembly initiated negotiations for an international legally binding instrument on plastic pollution (UNEA Resolution 5/14, 2022), which may establish new reporting requirements that complement ocean accounting frameworks. Compilers should monitor developments in this area.

3.3.2 Accounting for solid waste flows to marine environment

¶1 The SEEA solid waste account structure can be adapted for ocean accounting using the three approaches summarised in Table 3.3.2 below.

Approach	Description
Identifying marine leakage pathways	Waste that escapes from collection systems, landfills, or other waste management infrastructure and enters marine waters.
Recording direct dumping	Waste disposed directly into marine waters (regulated under the London Convention and Protocol).
Tracking coastal and riverine sources	Waste from coastal zones and rivers that enters the marine environment.

¶2 Compilation requires estimation of:

- ¶3 Waste generated by coastal industries and households
- ¶4 Share of mismanaged waste that reaches marine waters
- ¶5 Waste transported by rivers to the ocean
- ¶6 Waste generated by marine activities (shipping, fishing, offshore operations)

DRAFT

¶7 The European Waste Catalogue (EWC-Stat) classification provides a basis for categorising solid waste types, with particular attention to:

- ¶8 Plastic waste by polymer type and product category
- ¶9 Fishing gear (abandoned, lost, or discarded fishing gear — ALDFG)
- ¶10 Packaging waste
- ¶11 Single-use products

¶12 The SF-MST (Statistical Framework for Measuring the Sustainability of Tourism) provides guidance on tourism solid waste accounting that can inform measurement of coastal tourism waste generation [21].

¶13 **Plastic leakage estimation using the Jambeck approach**

¶14 The Jambeck et al. (2015) methodology [22] provides an accessible approach for estimating plastic waste leakage to the marine environment from land-based sources. The general formula is:

¶15 *Marine plastic leakage = Population in coastal zone × Waste generation rate (kg/person/year) × Share of plastic in waste × Share mismanaged × Share reaching marine environment*

¶16 Before applying this approach in a national account, compilers should verify that the following minimum data requirements are met:

- ¶17 A national waste characterisation study or official municipal solid waste (MSW) generation rate that establishes the per-capita waste generation rate and polymer composition of the waste stream. Where a recent national study is unavailable, regional benchmark data from the World Bank *What a Waste 2.0* report [23] may be used as a documented substitute.
- ¶18 An estimate of waste collection coverage (percentage of the coastal population served by formal collection), which is the primary driver of the "share mismanaged" parameter.

¶19 For the "share mismanaged" parameter, where country-specific data are unavailable, compilers should use the default values by income group in the reference table below, drawn from UNEP and World Bank sources. These values reflect the share of MSW that is inadequately managed (open dumping, burning, or uncontrolled disposal):

DRAFT

Country income group (World Bank classification)	Default share mismanaged (midpoint)	Indicative uncertainty range
Low income	0.90	0.80 – 0.99
Lower-middle income	0.52	0.35 – 0.70
Upper-middle income	0.22	0.10 – 0.40
High income	0.02	0.00 – 0.05

¶20 The original 2015 Jambeck coefficients for the "share reaching marine environment" parameter (ranging from 0.15 to 0.40 of mismanaged coastal waste) should be validated against more recent modelling estimates where available. Updated global plastic pollution models, including the SYSTEMIQ/UNEP analyses and the UNEP *Global Waste Management Outlook* (2024 edition) [24], provide revised leakage rate estimates by region and waste management system type. Where a compiler uses default coefficients, this should be documented in account metadata with a statement of the uncertainty range applied. Cross-reference with TG-4.2 Survey Methods for guidance on commissioning or interpreting national waste characterisation studies.

¶21 **Abandoned, lost, or discarded fishing gear (ALDFG)**

¶22 ALDFG is listed under the European Waste Catalogue classification and is specifically targeted by SDG 14.1 and the UN commitment on fishing gear marking. The following compilation note specifies how NSO compilers can produce a credible ALDFG estimate for inclusion in the solid waste supply side of the account.

¶23 *Step 1 — Gear inventory:* Use national fishing licence records and gear type declarations to establish the total quantity of gear in use, disaggregated by gear category (e.g., gillnets, longlines, pots and traps, drifting FADs, trawls). The FAO Voluntary Guidelines on the Marking of Fishing Gear (2019)[25] are the primary reference for gear inventory methodology and can be used to structure data collection from national licensing authorities.

¶24 *Step 2 — Apply gear-type-specific loss rates:* Apply published loss rate estimates from FAO/UNEP sources by gear type, for example:

- ¶25 Drifting FADs: 1-5% loss per deployment (Richardson et al., 2019)[26]
- ¶26 Longlines: 0.1-0.5% loss per set
- ¶27 Gillnets and trammel nets: 0.5-3% annual loss of gear stock
- ¶28 Pots and traps: 0.5-2% annual loss

¶29 Where country-specific or regional loss rate data are available from observer programmes or gear recovery surveys, these take precedence over global defaults.

¶30 *Step 3 — Express result:* Calculate the result as tonnes of gear material by polymer type per year (nylon, polyethylene, polypropylene, etc.), applying gear-type-specific material composition factors.

¶31 *Step 4 — Record in account:* Record under the solid waste supply side attributed to fishing, specifically ISIC 0311 (Marine fishing) or ISIC 0312 (Freshwater fishing) depending on the species group and operating area. Cross-reference TG-4.2 Survey Methods for gear survey design guidance.

3.4 Compilation Procedure for Physical Flow Accounts

¶1 The physical supply and use table for residuals records the generation of residuals by economic units (supply) and their destination (use). Table 1 provides a residual flow account template for ocean-related economic activities following the SEEA CF structure[27].

¶2 **Table 1: Residual Flow Account Template (Physical Supply-Use)**

¶3 **SUPPLY OF RESIDUALS** (by generating industry)

Residual Type	Fishing (ISIC 03)	Aquaculture (ISIC 03)	Shipping (ISIC 50)	Ports (ISIC 52)	Processing (ISIC 10)	Offshore Energy (ISIC 06)	Tou (ISI 55-5
Air emissions							
CO2 (tonnes)	45,000	2,000	850,000	15,000	120,000	180,000	8,00
SOx (tonnes)	180	8	12,000	60	450	720	30
NOx (tonnes)	320	15	18,000	110	680	1,100	55
Water emissions							
Nutrients - N (tonnes)	120	8,500	85	450	2,200	150	680
Nutrients - P (tonnes)	25	1,800	18	95	450	32	145
BOD (tonnes)	180	12,000	250	1,200	8,500	420	2,10
Solid waste							
Discarded catch (tonnes)	15,000	—	—	—	2,500	—	—
Plastic (tonnes)	450	85	1,200	320	680	125	2,80
General waste (tonnes)	850	220	5,600	2,400	4,200	950	8,50

¶4 *Note: totals are maintained per substance, never across substances. Adding tonnes of CO2 to tonnes of nitrogen and tonnes of plastic produces a number with no physical meaning, and SEEA CF*

DRAFT

Table 3.1 specifies per-substance totals for that reason[2]. The meaningful balancing check is that each substance row's supply equals its use.

¶5 **USE OF RESIDUALS** (by receiving medium or treatment)

Residual Type	Atmosphere	Direct discharge to coastal/marine water (point source)	Diffuse coastal runoff (non-point)	Riverine delivery (modelled/estimated)	Freshwate (drainage way-stati
CO2	1,245,000	–	–	–	–
SOx	13,448	–	–	–	–
NOx	20,280	–	–	–	–
Nutrients - N	–	3,200	2,100	3,900	[inland rete
Nutrients - P	–	680	450	820	[inland rete
BOD	–	7,200	5,500	7,800	[inland rete
Discarded catch	–	7,000	2,500	2,750	–
Plastic	–	1,700	1,650	1,500	–
General waste	–	2,100	2,100	1,900	–

¶6 *Note: This is a worked example with synthetic data illustrating the account structure. The supply-use identity requires Total Supply = Total Use for each residual type. The "Collection & Treatment" column records residuals that are collected by waste management industries rather than released directly to the environment. The use side distinguishes three marine water pathways as separate columns: (a) Direct discharge to coastal/marine water (point source, permit-regulated); (b) Diffuse coastal runoff (non-point, estimated); and (c) Riverine delivery (transported via freshwater system, modelled or estimated). These three columns appear at the same level as "Atmosphere" and "Seabed": there is no consolidated "Marine Water" parent column in this table. A "Freshwater/Inland" column records residuals generated within drainage basins that have not yet reached the coast and acts as a way-station consistent with the drainage basin methodology in Section 3.5.3. Atmospheric emissions may subsequently deposit in marine waters but are recorded in the atmosphere use column following SEEA CF convention. See Table M1 in Section 3.2.2 for the supplementary atmospheric deposition memorandum table.*

¶7 *Data sources by use sub-column: (a) Direct discharge — discharge permit records, point-source monitoring; (b) Diffuse coastal runoff — land cover analysis, runoff modelling, stormwater monitoring; (c) Riverine delivery — river load monitoring, watershed modelling (e.g., Global NEWS). See TG-4.3 Administrative Data Sources.*

¶8 **What this one table stands in for.** The SEEA Central Framework specifies several separate physical flow accounts, each with its own table. This Circular compiles them as one ocean-scoped PSUT rather than reproducing each separately, because an ocean account needs the substances routed to a common set of marine receiving media and a compiler reconciling five tables to one boundary gains nothing. The correspondence is:

SEEA CF account	Where it appears here	Reconciling to a national account
Air emissions account	CO2, SOx, NOx rows; Atmosphere use column	Row totals should equal the ocean-industry columns of the national air emissions account
Water emissions account	Nutrients, BOD rows; the three marine-water and freshwater use columns	Row totals should equal the national water emissions account for the same industries, with the marine split added here
Solid waste account	Discarded catch, plastic, general waste rows; Collection & Treatment and Recycling columns	Row totals should equal the national waste account for the same industries

DRAFT

SEEA CF account	Where it appears here	Reconciling to a national account
Energy flow account	Not compiled here	**TG-3.10 Offshore Energy Accounts**
Water flow account	Seawater abstraction is a natural input, not a residual	**TG-3.2** Section 3.3.1; freshwater-marine interaction in **TG-6.13**

¶9 Where a country already publishes air, water-emission or waste accounts, compile this table by extracting and re-routing those rows rather than by independent estimation, and reconcile the totals. Where it does not, this table is the first of them.

3.4.1 Compilation steps

¶1 The compilation procedure for residual flow accounts follows these steps:

¶2 **Step 1: Identify industries in scope**

¶3 Determine which industries generate material quantities of residuals that reach marine waters, either directly or indirectly. Use the ISIC classification framework detailed in TG-3.3 Economic Activity Relevant to the Ocean. At minimum, include:

- ¶4 Marine-based industries: fishing (ISIC 03), shipping (ISIC 50), offshore extraction (ISIC 06)
- ¶5 Coastal industries: aquaculture (ISIC 03), ports (ISIC 52), fish processing (ISIC 10), coastal tourism (ISIC 55-56)
- ¶6 Land-based sources: agriculture (ISIC 01), manufacturing (ISIC 10-33), sewerage (ISIC 37)
- ¶7 Households in coastal drainage basins

¶8 **Step 2: Determine substance priorities**

¶9 Select substances based on policy relevance, data availability, and environmental significance. Priority substances typically include:

- ¶10 Air emissions: CO2, SOx, NOx (linked to acidification and deposition)
- ¶11 Water emissions: nitrogen, phosphorus, BOD, COD, heavy metals, oil
- ¶12 Solid waste: plastics (by type), fishing gear, general waste

¶13 **Step 3: Compile supply-side data**

¶14 For each industry-substance combination, estimate the quantity generated using:

- ¶15 Direct measurement from monitoring systems (e.g., continuous emissions monitoring)
- ¶16 Activity data × emission factors (e.g., fuel consumption × CO2 coefficient)
- ¶17 Industry surveys and reporting systems
- ¶18 Administrative records (discharge permits, waste manifests)
- ¶19 Modelling (e.g., nutrient loading models for agriculture)

¶20 Sources are detailed in Section 4 (Data Sources and Compilation).

¶21 **Step 4: Compile use-side data**

¶22 Track the destination of residuals:

- ¶23 Atmosphere: all air emissions by convention
- ¶24 Marine water (direct discharge): point source releases directly to coastal or marine water
- ¶25 Marine water (diffuse coastal runoff): non-point source releases estimated from land cover and runoff data
- ¶26 Marine water (riverine delivery): loads transported via freshwater systems and modelled to reach the coast
- ¶27 Freshwater/Inland: residuals generated within drainage basins not yet delivered to marine waters

DRAFT

- ¶28 Seabed: dumped waste, settled solids
- ¶29 Collection & treatment: residuals entering waste management systems
- ¶30 Recycling: recovered materials

¶31 **Step 5: Balance supply and use**

¶32 Verify that Total Supply = Total Use for each substance. Discrepancies indicate:

- ¶33 Missing treatment/disposal pathways
- ¶34 Unaccounted intermediate flows (e.g., retention in soils or freshwater systems)
- ¶35 Measurement error requiring reconciliation

¶36 Where discrepancies arise between supply-side estimates (e.g., from industry surveys or emission factors) and use-side estimates (e.g., from water quality monitoring networks), the following reconciliation sub-steps apply in sequence:

¶37 **(i) Document** the size and sign of the discrepancy for each substance and each use column.

¶38 **(ii) Investigate** in priority order: first check for missing pathways (a residual category may have no assigned use column), then check for unaccounted intermediate flows, and finally investigate measurement error.

¶39 **(iii) Apply adjustments** to the side with lower data quality. Where one side is based on direct measurement (e.g., flow gauging and water quality sampling at a river mouth) and the other on modelled estimates, adjust the modelled side to reconcile with the measured side. Document the direction of the adjustment and the reason.

¶40 **(iv) Record adjustments in metadata**, including the pre-adjustment and post-adjustment values for each substance and the rationale for the adjustment applied.

¶41 **(v) Present a reconciliation statement** showing pre- and post-adjustment totals for each substance as a standard annex to the account publication. This facilitates time-series comparability and supports quality assurance review.

¶42 Cross-reference TG-0.7 Quality Assurance for general principles on reconciliation and documentation standards.

¶43 **Step 6: Extend with spatial disaggregation**

¶44 Where feasible, disaggregate accounts by:

- ¶45 Drainage basin (for land-based sources) — see Section 3.5.3
- ¶46 Marine area (coastal zone, EEZ zones)
- ¶47 Ecosystem receiving area (coral reef, mangrove, open water)

¶48 This spatial extension supports targeted pressure assessment and links to ecosystem condition accounts.

3.5 Attribution to Economic Sectors

¶1 A principle of environmental-economic accounting is the attribution of residual flows to the economic units responsible for their generation. This attribution enables:

- ¶2 Analysis of which industries contribute most to environmental pressures
- ¶3 Assessment of intensity (emissions per unit output or value added)
- ¶4 Policy targeting and evaluation
- ¶5 Responsibility allocation for environmental management

3.5.1 Classification framework

¶1 The International Standard Industrial Classification of All Economic Activities (ISIC) provides the standard framework for classifying economic units by industry[28]. Detailed guidance on ISIC appli-

DRAFT

cation for ocean-related activities is provided in TG-3.3 Economic Activity Relevant to the Ocean. Key industries for ocean-related residual flows include:

¶2 **Primary industries**

- ¶3 ISIC 01-03: Agriculture, forestry and fishing — sources of nutrient runoff, aquaculture discharges
- ¶4 ISIC 05-09: Mining and quarrying — offshore extraction discharges, drilling wastes

¶5 **Manufacturing**

- ¶6 ISIC 10-33: Manufacturing — industrial discharges, waste generation, including fish processing (ISIC 1020)

¶7 **Utilities and waste management**

- ¶8 ISIC 35: Electricity, gas, steam and air conditioning supply — cooling water discharges, emissions from power generation
- ¶9 ISIC 36-39: Water supply, sewerage, waste management — wastewater discharges, solid waste flows

¶10 **Transport**

- ¶11 ISIC 50: Water transport — vessel emissions and discharges, ballast water, operational waste
- ¶12 ISIC 52: Warehousing and support activities for transportation — port operations

¶13 **Tourism and recreation**

- ¶14 ISIC 55-56: Accommodation and food service — coastal tourism waste and wastewater
- ¶15 ISIC 79: Travel agency and related activities — tourism-related pressures
- ¶16 ISIC 93: Sports, amusement and recreation — marine recreation impacts

¶17 **Construction**

- ¶18 ISIC 41-43: Construction — coastal development, dredging, infrastructure installation

¶19 Table 2 provides an illustrative example of how key residual types can be attributed to the industries that generate them, following the ISIC classification used in TG-3.3 Economic Activity Relevant to the Ocean.

DRAFT

¶20 **Table 2: Illustrative Attribution of Residual Types to Ocean Industries**

Residual Type	Primary Ocean Industries	Attribution Approach	Data Sources
CO2 emissions	Shipping (ISIC 50), Offshore energy (ISIC 06)	Fuel consumption data × emission factor	Fuel sales, vessel monitoring, IMO reporting
Nutrient loading (N, P)	Agriculture (ISIC 01), Aquaculture (ISIC 03)	Activity data × emission factor; nutrient balance models	Fertilizer sales, livestock numbers, aquaculture feed records
Plastic waste	Fishing (ISIC 03), Tourism (ISIC 55-56), Households	Waste surveys; consumption data × leakage rates	Waste characterisation studies, gear loss surveys
BOD/organic waste	Aquaculture (ISIC 03), Food processing (ISIC 10), Sewerage (ISIC 37)	Production data × waste coefficient; monitoring	Discharge permits, treatment plant records
Underwater noise	Shipping (ISIC 50), Construction (ISIC 42)	Vessel movements × acoustic profile; pile-driving events	AIS data, construction permits, acoustic modelling
Oil & petroleum	Shipping (ISIC 50), Offshore extraction (ISIC 06)	Spill records; operational discharge monitoring	Incident reports, platform monitoring

3.5.2 Attribution methodology

¶1 The physical supply table for residuals records the generation of residuals by industry sector, with the use table recording their destination (collection by waste management, flows to environment)[29]. Key methodological considerations include:

1. ¶2
   Point source versus non-point source — point sources can be directly attributed to specific industries, whilst non-point sources (e.g., agricultural runoff, urban stormwater) require modelling or allocation methods
2. ¶3
   Direct versus indirect flows — industries may generate residuals that flow directly to the environment or that are collected by other economic units (e.g., sewerage industry) before environmental release
3. ¶4
   Residence principle — following national accounts conventions, residual flows are attributed to the resident economic unit generating them, regardless of where the release occurs. This is particularly relevant for shipping, where vessel emissions in foreign or international waters are attributed to the country of the vessel operator's residence[30]
4. ¶5
   Territorial versus production-based attribution — the default boundary for TG-3.4 residual flow accounts is the territorial boundary, consistent with SEEA CF Chapter 2 conventions for environmental accounts (paragraphs 2.14-2.30). Production-based accounts are a supplementary presentation only. Both supply and use sides of the account must use the same boundary. Mixing boundaries will cause the supply-use identity to fail, and Table 1 will not balance.
   Worked example — vessel CO2 emissions under each boundary:
   - ¶6 Under the territorial boundary, a foreign-flagged vessel emitting 500 tonnes CO2 while transiting the national EEZ is included in the national account, whilst a nationally-flagged vessel emitting 2,000 tonnes CO2 outside the EEZ is excluded.
   - ¶7 Under the production-based (residence) boundary, the same nationally-flagged vessel's 2,000 tonnes CO2 is included regardless of where the emissions occur, whilst the foreign-flagged vessel's 500 tonnes are excluded.
   - ¶8 Compilers must apply one boundary consistently to both the supply side (industry emission totals) and the use side (marine area receiving the emissions). The SEEA Technical Note on Air Emissions provides further guidance on the residence principle[30].
5. ¶9
   Consumption-based attribution — for a fuller assessment, consumption-based attribution allocates emissions embodied in imported goods to the consuming economy. This requires input-output analysis linking production emissions to final consumption[31]

3.5.3 Spatial attribution using drainage basins

¶1 A key challenge in ocean accounting is attributing land-based pollution flows to specific marine areas. Drainage basins (the geographic areas from which surface water flows to a common outlet such as a river mouth or coastal discharge point) provide a natural spatial framework for linking terrestrial economic activity to marine pollution pressures[32]. By overlaying information on economic activity and population distribution with drainage basin boundaries, compilers can estimate the contributions of specific land areas to residual flows reaching the coast.

¶2 **Allocation from national totals**

¶3 Where SEEA CF water emission accounts or solid waste accounts have been compiled at the national level, these totals can be allocated to drainage basins using spatially detailed indicators of economic activity. For example, if the national water emissions account records that agriculture generates 5,000 tonnes of biological oxygen demand (BOD) per year, and a particular drainage basin contains 60% of the nation's agricultural employment, an initial estimate of BOD generated

DRAFT

by agriculture in that basin would be 3,000 tonnes per year. This activity-proportional allocation approach can be applied to any industry for which suitable spatial indicators are available, such as employment counts, output data, or land-use statistics [33].

¶4 The allocation formula is:

¶5 *Residual flow in basin i = National residual flow × (Activity indicator in basin i / National activity indicator)*

¶6 Example spatial indicators by industry:

- ¶7 Agriculture (ISIC 01): agricultural employment, fertiliser sales by district, irrigated area
- ¶8 Manufacturing (ISIC 10-33): industrial employment, facility locations, output by region
- ¶9 Households: population in drainage basin, housing units
- ¶10 Aquaculture (ISIC 03): licensed farm locations, production tonnage by basin

¶11 ⚠ **Method validity check**

¶12 Activity-proportional allocation assumes that emission intensity per unit of activity is broadly uniform across basins. This assumption holds reasonably well when the spatial distribution of key drivers (crop type, technology mix, soil class, and management practice) is relatively homogeneous. It breaks down when documented heterogeneity exists across basins: for example, a coastal basin with intensive irrigated rice cultivation will have materially different nitrogen leaching coefficients from an inland basin with dryland cropping, even if both have similar agricultural employment totals.

¶13 Where spatial heterogeneity in emission intensity is likely to be pronounced, compilers should apply one of the following alternatives, in order of preference:

¶14 **(a) Facility-level data for point sources** — where individual facility emission data are available (discharge permits, monitoring records), these take precedence over proportional allocation for point sources.

¶15 **(b) Land-cover-differentiated emission factors for agriculture** — apply separate emission factors by crop type and management system (e.g., paddy rice, dryland cereal, irrigated vegetables) rather than a single national average, using land cover or agricultural census data disaggregated by basin.

¶16 **(c) Documented assumption with bias direction** — where heterogeneity is known but alternatives are unavailable, continue to use the proportional allocation method but document in account metadata that the assumption is likely to (overstate/understate) loads in particular basins, and in which direction.

DRAFT

¶17 **Bottom-up estimation from activity data**

¶18 Where no SEEA CF flow accounts exist at the national level, compilers can estimate residual flows by applying per-unit emission or waste generation factors to spatially detailed data on economic activity and population. For example, if 5,000 people reside within a drainage basin and the estimated per-capita generation rate of untreated solid waste is 0.365 tonnes per year, the population in that basin generates approximately 1,825 tonnes of untreated solid waste annually. Such per-capita and per-unit factors may be drawn from national waste surveys, regional studies, or international benchmarks and applied to census or administrative data at the drainage basin level.

¶19 General formula:

¶20 *Residual flow = Activity level × Emission/waste factor*

¶21 Example emission factors:

- ¶22 Nutrient loading from agriculture: kg N per hectare of fertilised cropland
- ¶23 BOD from households: kg BOD per capita per year for unsewered population
- ¶24 Plastic waste: kg plastic per capita per year × share mismanaged × share reaching marine environment

¶25 **Delivery ratio: tiered fallback methodology**

¶26 Not all residuals generated within a drainage basin reach the ocean. Soils retain some pollutants and vegetation absorbs others. Freshwater systems store a further portion, and transport losses reduce the quantities that remain. Treatment systems (sewerage networks, wastewater treatment plants) intercept and process portions of the load before discharge. The delivery ratio is the

proportion of residuals generated within the basin that are estimated to reach marine waters. Compilers should apply the following tiered fallback methodology when a delivery ratio is required:

¶27 **Tier 1 — National hydrology agency data:** If a government hydrology agency or national environmental authority has published delivery ratios for river basins or pollutant types (e.g., from a national water quality model or regulatory catchment assessment), these values should be applied and cited as the primary source.

¶28 **Tier 2 — Published regional defaults:** Where Tier 1 data are unavailable, use published regional default delivery ratios from sources including:

- ¶29 The Global NEWS (Nutrient Export from WaterSheds) model, which provides nitrogen, phosphorus, and organic carbon delivery coefficients by river basin globally (Mayorga et al., 2010)[34]
- ¶30 FAO AQUASTAT nutrient export coefficients, which provide country- and region-level estimates for nitrogen and phosphorus delivery to water bodies

¶31 **Tier 3 — Conservative default (1.0):** Where neither Tier 1 nor Tier 2 data are available, treat the delivery ratio as 1.0, meaning that all generated residuals are assumed to reach marine waters. This is a conservative overestimate and will tend to overstate coastal loads. Accounts compiled using Tier 3 must be labelled in metadata as reporting "generated load, not delivered load". SEEA CF-consistent accounts may use this approach provided the labelling is clear and the assumption is documented.

¶32 A formal metadata field distinguishing generated residuals (all sources within the basin, prior to delivery adjustment) from delivered residuals (the portion estimated to reach marine waters) should be included in all drainage basin accounts. This distinction is relevant to policy users comparing accounts across countries or jurisdictions, where different delivery ratio approaches may have been applied.

¶33 For example, if agricultural activities generate 3,000 tonnes BOD per year in a drainage basin, and watershed modelling (Tier 1) indicates a 35% delivery ratio, the delivered load is 1,050 tonnes BOD per year. If no delivery ratio data are available, the Tier 3 entry would record 3,000 tonnes as generated load with a metadata flag.

DRAFT

¶34 **Marine redistribution**

¶35 Conversely, residuals that do reach the ocean may not remain at the point of coastal discharge, as ocean currents, tides, and biogeochemical processes redistribute pollutants over time and space. Further dispersion modelling would be required for more precise estimates of marine pollution loading and exposure patterns. Nonetheless, linking land-based sources of pollution with coastal and marine conditions through drainage basin attribution is a first step in connecting economic drivers to environmental outcomes.

¶36 **Implementation guidance**

¶37 Including terrestrial and freshwater areas in the spatial database underlying ocean accounts facilitates estimation of land-based sources of pollution and supports integrated catchment-to-coast analysis as outlined in TG-3.1 Asset Accounts. Practical steps include:

1. ¶38 Obtain drainage basin boundaries from hydrological datasets (national water agencies, HydroSHEDS, regional GIS layers)
2. ¶39 Overlay economic activity data (employment, facilities, land use) using GIS
3. ¶40 Calculate activity shares by basin for each relevant industry
4. ¶41 Apply shares to national residual flow totals, or apply emission factors to basin-level activity data
5. ¶42 Adjust for treatment coverage and delivery ratios where data permit (see tiered fallback methodology above)

6. ¶43 Document methodology, data sources, and assumptions in account metadata, including which delivery ratio tier was applied and whether the account reports generated or delivered residuals

¶44 This methodology supports policy analysis by identifying:

- ¶45 Which drainage basins contribute most to coastal pollution
- ¶46 Which industries within priority basins require intervention
- ¶47 Where land-use planning and waste infrastructure investments would have greatest marine benefit

¶48 Guidance on linking these residual flow estimates to marine ecosystem condition and pressure indicators is provided in TG-2.7 Pollution and Other Flows to Environment.

Land-to-sea attribution across the coastal interface

¶1 Accounts that span the land-sea interface require Basic Spatial Units harmonised across the terrestrial and marine domains, and a rule for apportioning terrestrial pressures to the marine units that receive them. The recommended approach is **drainage basin allocation**: identify the sub-catchments draining to each coastal BSU, then apportion terrestrial pressures (nutrient loading, sediment, pollutants) to marine receiving BSUs using a hydrological weighting factor derived from relative catchment area and runoff volume. GIS intersection is the standard technical method for this attribution. For first compilations, mapping coastal watershed polygons to the nearest marine BSU is an acceptable simplification. BSU design should match the resolution of available data, with no fixed resolution prescribed. BSU design follows **TG-2.12 Spatial Data Frameworks** Section 3.3; see also ESCAP (2021) *Ocean Accounts: Piloting the SEEA EEA for the Ocean*, Chapter 3, and SEEA EA paras 3.29–3.44. The integrated coastal management use of this attribution is set out in **TG-1.4 OA and Sustainable Ocean Planning** Section 3.5.

DRAFT

3.6 Physical Pressures

¶1 Beyond material pollution, economic activities exert physical pressures on marine ecosystems that do not involve material flows but nonetheless affect ecosystem condition and function. These pressures are recognised in ecosystem accounting frameworks, including SEEA Ecosystem Accounting guidance on ecosystem condition indicators [35].

3.6.1 Underwater noise

¶1 Anthropogenic underwater noise is a marine pressure of particular relevance to marine mammals and other species that rely on acoustic communication and echolocation [36]. Table 3.6.1 below summarises the principal sources.

Source	Description
Shipping	Continuous low-frequency noise from vessel propulsion and machinery.
Seismic surveys	High-intensity impulsive noise from airguns used in oil and gas exploration.
Pile driving	High-intensity impulsive noise from construction of offshore infrastructure including wind farms.
Sonar	Military and commercial sonar systems.
Dredging and drilling	Operational noise from coastal and offshore construction.

¶2 The Classification of Environmental Protection Activities (CEPA) includes noise and vibration abatement (CEPA 5), covering activities aimed at control, reduction, and abatement of industrial and transport noise [37]. For ocean accounting, this framework can be adapted to address underwater noise from maritime activities.

¶3 Accounting for underwater noise requires:

- ¶4 Identification of noise-generating activities and their acoustic characteristics
- ¶5 Spatial mapping of noise exposure in marine areas
- ¶6 Attribution to economic sectors responsible for noise generation
- ¶7 Recording of mitigation measures (e.g., speed reductions, operational restrictions, noise barriers)

¶8 Underwater noise measurement remains an emerging field with limited standardisation. The IMO has developed voluntary guidelines for reducing underwater noise from commercial shipping (MEPC.1/Circ.833)[38], and several regional seas conventions have adopted noise monitoring indicators, including EU MSFD Descriptor 11, which establishes a good environmental status criterion for ambient noise levels. Until a standardised acoustic unit is adopted internationally, compilers should use the following primary proxy indicators for NSO compilation:

- ¶9 **Shipping noise:** AIS-derived vessel density (vessel-hours per km² per year) within the national EEZ or defined marine accounting area, attributed to Water Transport (ISIC 50). This proxy represents the spatial and temporal pattern of shipping activity (the primary driver of continuous low-frequency noise), using existing AIS data that many NSOs or coast guard authorities already receive.
- ¶10 **Construction noise:** Number of pile-driving events per year, attributed to Construction (ISIC 42) or Electricity/gas supply (ISIC 35) for offshore wind installations.

¶11 A secondary recommended indicator, to be compiled where acoustic monitoring data are available, is the percentage of the national EEZ exceeding an ambient noise threshold (expressed in dB re 1 µPa in a defined frequency band). This indicator is flagged as emerging and subject to methodological revision as international standardisation develops. Compilers using this secondary indicator should document the threshold, frequency band, and monitoring method in account metadata and cross-reference TG-0.7 Quality Assurance for the treatment of experimental indicators.

3.6.2 Light pollution

¶1 ⓘ **Future Directions**

¶2 **Artificial light at night (ALAN) as a marine pressure indicator — not yet compilable at NSO level**

¶3 Artificial light at night affects marine and coastal ecosystems by disrupting navigation, reproduction, and predator-prey relationships for marine species including sea turtles, seabirds, and coral spawning[39]. Sources include coastal urban lighting, offshore platform lighting, vessel lighting, and fishing operations using light attraction.

¶4 At the time of this Circular's publication, light pollution has not been adopted as a statistical standard within the SEEA CF or SEEA EA frameworks, and no CEPA classification covers light pollution. An NSO compiler cannot yet derive a light pollution account that is compliant with an agreed international standard. This section is therefore designated as a future direction and compilers are advised not to treat it as a current data requirement.

¶5 **Single operational proxy for monitoring purposes:** Compilers seeking to develop a supplementary earth observation indicator may use VIIRS (Visible Infrared Imaging Radiometer Suite) Day/Night Band night-light radiance, expressed in nW/cm²/sr, aggregated over the coastal zone and offshore platform locations within the national accounting area. VIIRS DNB data are available from the NOAA/NCEI Earth Observations Group at 750 m resolution and cover the period from 2012 onwards, enabling time-series construction. This indicator is derived from earth observation and is not an economic accounting flow. It should be presented separately from the core residual flow account.

¶6 Full accounting treatment of light pollution as an economic-to-environment flow, including industry attribution and classification standards, is deferred to a future revision of this Circular pending development of an appropriate statistical standard. See TG-4.1 Remote Sensing and Geospatial Data for guidance on integrating satellite-derived supplementary indicators into the ocean accounts system.

3.6.3 Habitat disturbance

¶1 Physical disturbance of marine habitats results from activities summarised in Table 3.6.3 below.

DRAFT

Activity	Description
Bottom trawling	Physical impact on seabed habitats from mobile fishing gear.
Dredging	Removal of sediments from ports, channels, and coastal areas.
Coastal development	Construction affecting coastal and nearshore habitats.
Cable and pipeline installation	Seabed disturbance from infrastructure installation.
Anchoring	Localised damage from vessel anchoring, particularly on sensitive habitats such as seagrass and coral.

¶2 The SEEA Ecosystem Accounting framework addresses ecosystem modification and habitat disturbance as factors affecting ecosystem condition [35]. For ocean accounting, physical pressures should be recorded in terms of:

- ¶3 Area affected by disturbance type and economic activity
- ¶4 Intensity or severity of disturbance
- ¶5 Recovery status where applicable

¶6 Guidance on linking physical pressures to ecosystem condition accounts is provided in TG-3.1 Asset Accounts Section 3.5.2.

3.7 Combined Presentations and Indicators

¶1 The SEEA framework supports combined presentations that bring together physical and monetary data to enable derivation of indicators [40]. For residual flows to the marine environment, combined presentations would include:

¶2 **Table 3: Combined Presentation Framework for Ocean-Related Residual Flows**

Data Element	Physical Units	Monetary Units
Output by industry	tonnes, units	Currency
Gross value added by industry	–	Currency
Employment by industry	Persons, FTE	–
Emissions to water by substance	tonnes	–
Emissions to air by substance	tonnes	–
Solid waste generated	tonnes	–
Waste management expenditure	–	Currency
Environmental protection expenditure	–	Currency
Environmental taxes paid	–	Currency

DRAFT

¶3 **Methodology note for intensity indicators**

¶4 The following methodological specifications apply when deriving intensity indicators from Table 3:

¶5 **(a) Economic denominator:** Use gross value added (GVA) at basic prices, current prices, for the same reference year as the physical account. GVA at basic prices is the recommended aggregate for industry-level analysis as it excludes taxes on products, which vary across industries and jurisdictions (SNA 2025, Chapter 6) [41]. The relevant national accounts aggregate should match the ISIC industry classification in the physical account.

¶6 **(b) Industry classification:** Industry classification for GVA denominators follows ISIC, consistent with TG-3.3 Economic Activity Relevant to the Ocean. Where national accounts publish GVA at a more aggregated ISIC level than the physical account, compilers should document the correspondence applied.

¶7 **(c) Households:** Households have no GVA. For household-generated residuals, use household final consumption expenditure as the economic denominator, or present household residuals on a per capita basis as an alternative intensity measure. Do not leave the household row blank in the intensity table. Flag the denominator used.

¶8 **(d) Accounting period:** The default accounting period is the calendar year (1 January to 31 December). Where national accounts are compiled on a fiscal year basis that differs from the calendar year, document the adjustment applied to align physical and monetary data for the intensity calculation.

¶9 From such presentations, indicators can be derived including:

- ¶10 **Emissions intensity**: emissions per unit GVA or output (e.g., kg N per million currency of aquaculture output)
- ¶11 **Waste generation intensity**: tonnes waste per FTE (e.g., kg plastic per employee in fishing industry)
- ¶12 **Environmental expenditure share**: environmental expenditure as percentage of industry output
- ¶13 **Decoupling indicators**: tracking emissions relative to economic growth (e.g., ratio of emission growth rate to GDP growth rate)

¶14 Example derived indicators:

Industry	Nutrient Loading (tonnes N)	Gross Value Added (million currency, basic prices)	Intensity (kg N per million GVA)
Aquaculture (ISIC 03)	8,500	450	18,889
Agriculture (ISIC 01)	85,000	2,300	36,957
Households	3,200	— (use per capita: 3,200 t N ÷ — population)	

¶15 In this example, whilst agriculture generates a larger absolute load, aquaculture has lower emissions intensity per unit of economic output. Such indicators support:

- ¶16 Benchmarking across industries and jurisdictions
- ¶17 Monitoring progress toward pollution reduction targets
- ¶18 Identifying high-intensity activities for policy intervention
- ¶19 Evaluating effectiveness of environmental protection expenditure

¶20 Guidance on indicator derivation and interpretation is provided in TG-2.7 Pollution and Other Flows to Environment and TG-2.11 Resource Efficiency.

3.8 Cross-Stack Connections

¶1 Residual flow accounts sit at the centre of an integrated information system linking economic drivers, environmental pressures, ecosystem condition, and policy responses:

¶2 **Upward connections (to indicators and policy frameworks):**

- ¶3 TG-2.7 Pollution and Other Flows to Environment — derives pressure indicators from residual flow data (nutrient loading rates, plastic leakage, emission trends)
- ¶4 TG-2.8 Climate Change Indicators — links CO2 emissions to ocean acidification indicators and climate-related marine impacts
- ¶5 SDG 14.1.1 — coastal eutrophication index draws on nutrient loading data, whilst floating plastic debris density draws on plastic waste flows
- ¶6 TNFD disclosures — plastic pollution metrics and pollution-related dependencies

¶7 **Downward connections (to data sources):**

- ¶8 TG-4.2 Survey Methods — industry surveys on waste generation, environmental practices
- ¶9 TG-4.3 Administrative Data — discharge permits, compliance monitoring, waste manifests, ship reporting systems
- ¶10 TG-4.1 Remote Sensing and Geospatial Data — satellite detection of oil spills, floating debris, coastal development
- ¶11 National pollution inventories, water quality monitoring networks, marine litter surveys

¶12 **Lateral connections (to related physical accounts):**

- ¶13 TG-3.1 Asset Accounts — links residual flows to changes in asset quality (water quality degradation, seabed contamination)
- ¶14 TG-3.2 Flows from Environment to Economy — contrasts resource extraction flows with waste return flows
- ¶15 TG-3.3 Economic Activity — provides ISIC framework for industry attribution

¶16 Through these connections, residual flow accounts contribute to a coherent analytical framework.

3.9 Monetary Valuation of Residual Flows

¶1 Residual flows from the economy to the marine environment are recorded primarily in physical terms in the SEEA Central Framework. Monetary valuation of these flows is not required by the SEEA CF but is sometimes attempted in supplementary analyses, particularly where the same residual is also an ecosystem-service disservice (for example, greenhouse-gas emissions reducing the global climate regulation service of the ocean) or where compilers wish to express pressures in monetary units to support cost-benefit analysis and integrated reporting. The NCAVES/MAIA technical guidance on monetary valuation [42], although developed for ecosystem-service flows in the SEEA EA, provides the most coherent published set of patterns for valuing the marine impacts of residual flows.

3.9.1 Exchange-value framing for residual flows

¶1 The same exchange-value concept that governs ecosystem-service valuation in TG-3.2 Flows from Environment to Economy applies in principle to residual flows: where a market price for the right to discharge exists (for example, allowances under a regulated emissions trading system), that price represents an exchange value and can be used directly. Where no such market exists, valuation must fall back on revealed-expenditure or simulated-expenditure methods. Compilers should be alert to the distinction between **exchange values** (usable in monetary accounts) and **welfare values** such as willingness to pay to avoid the residual, which include consumer surplus and are conceptually distinct from accounting prices [43]. Where stated-preference techniques are the only feasible source of evidence, the **simulated exchange value (SEV)** method can in principle be used to convert welfare estimates to accounting-consistent prices, though this remains a frontier application.

3.9.2 Candidate valuation methods by residual type

¶1 For tiered valuation approaches and the NCAVES framework for selecting candidate methods by residual category, see **TG-3.2 Flows from Environment to Economy**, Section 3.5. None of those methods is required by SEEA CF. All should be treated as candidate workflows accompanied by clear documentation of methods, assumptions, and uncertainties. The replacement cost and avoided damage cost methods are valid proxies for exchange value only where three conditions hold: the alternative or damage measure corresponds to the actual function being valued, it represents the least-cost option, and there is evidence that society would in fact undertake the response [44].

3.9.3 Asset-side implications and discount rate

DRAFT

¶1 Where residual flows degrade ecosystem condition, they reduce the future supply of ecosystem services and therefore reduce the **net present value (NPV)** of the affected ecosystem asset. This is the **degradation** concept in SEEA EA: monetary degradation equals the change in asset value attributable to the decline in condition. The NPV calculation requires both a projected future flow path and a discount rate.

¶2 For discount rate selection (including the Ramsey decomposition, the distinction between market-based and social discount rates, plausible SDR ranges, and government guidance schedules), see **TG-1.9 Safe Usage of Monetary Valuation** Section 3.1.2. Compilers attempting damage-side valuations of residual flows should adopt rates specified in relevant national guidance, document the choice, and present sensitivity analyses across at least two alternative rates consistent with TG-1.9 Section 3.1.2.

> ¶3 ⚠ **Common Misconception**
> ¶4 The **social cost of carbon (SCC)** is a welfare measure, not an exchange value. Use ETS prices or marginal abatement cost estimates for accounting-consistent carbon pricing[45]. See **TG-3.2 Flows from Environment to Economy** Section 3.5 for the full exchange-value versus welfare-value treatment.

¶5 These valuations remain a frontier area for ocean accounting. The NCAVES guidance is explicit that monetary valuation of pressures and damages should be undertaken cautiously, with full disclosure of methods and uncertainty, and should not displace the underlying physical accounts that remain the primary record of residual flows under the SEEA CF.

4. Data Sources and Compilation

¶1 Compilation of residual flow accounts for ocean accounting draws on multiple data sources. TG-4.3 Administrative Data provides detailed guidance on administrative data sources for ocean accounting.

¶2 Key data sources include:

¶3 **Environmental monitoring data**

- ¶4 National pollution inventories and emission reporting systems
- ¶5 Water quality monitoring networks (coastal stations, estuarine monitoring)
- ¶6 Marine litter surveys and monitoring programmes
- ¶7 Beach cleanup data and citizen science initiatives

¶8 **Administrative records**

- ¶9 Discharge permits and compliance monitoring (point sources)
- ¶10 Waste management records and tracking systems
- ¶11 Port reception facility records (MARPOL waste from vessels)
- ¶12 Ship monitoring and reporting systems (fuel consumption, ballast water exchange)
- ¶13 Aquaculture licensing and feed records

¶14 **Survey data**

- ¶15 Industry surveys on environmental practices
- ¶16 Waste characterisation studies
- ¶17 Tourism surveys for visitor-generated waste estimation
- ¶18 Fishing gear loss surveys

¶19 **Modelling and estimation**

- ¶20 Atmospheric deposition models (linking air emissions to marine deposition)
- ¶21 River loading models (watershed models estimating pollutant delivery)

DRAFT

- ¶22 Waste leakage models (e.g., Jambeck methodology for plastic waste)[22]
- ¶23 Nutrient balance models for agriculture

¶24 **International reporting frameworks**

- ¶25 UNFCCC greenhouse gas inventories (CO2, CH4, N2O by sector)
- ¶26 UNECE Convention on Long-Range Transboundary Air Pollution reporting
- ¶27 Regional seas convention reporting (e.g., OSPAR, HELCOM, Barcelona Convention)
- ¶28 IMO reporting under MARPOL (vessel discharges and emissions)

¶29 **Example data pathway 1: Nutrient loading from agriculture**

1. ¶30 **Activity data**: Agricultural census provides hectares of cropland by district and drainage basin
2. ¶31 **Emission factor**: National studies estimate 45 kg N per hectare leached from fertilized cropland
3. ¶32 **Initial estimate**: 10,000 hectares in Coastal Basin A × 45 kg N/ha = 450,000 kg N generated
4. ¶33 **Delivery adjustment**: Watershed model indicates 35% delivery ratio to coast → 157,500 kg N delivered
5. ¶34 **Account entry**: Agriculture (ISIC 01) in Basin A contributes 157.5 tonnes N to coastal waters

¶35 **Example data pathway 2: Plastic waste to marine environment**

1. ¶36 **Activity data**: National MSW statistics provide total waste generation (tonnes/year) for the coastal population. Apply waste characterisation study results (or World Bank *What a Waste 2.0* regional benchmark) to derive the plastic fraction in tonnes.
2. ¶37 **Mismanaged share**: Apply the income-group default "share mismanaged" from the reference table in Section 3.3.2 (the income-group default table under "Accounting for solid waste flows to marine environment"), or country-specific collection coverage data if available.
3. ¶38 **Leakage coefficient**: Apply the Jambeck "share reaching marine environment" coefficient for the coastal population (validate against updated SYSTEMIQ/UNEP estimates where available).
4. ¶39 **Marine litter estimate**: Tonnes plastic mismanaged × leakage coefficient = estimated marine plastic leakage per year.
5. ¶40 **Reconciliation note**: Where beach monitoring data or river plastic flux monitoring are available, present a reconciliation comparison between the model estimate and observed data and document any adjustment applied.
6. ¶41 **Account entry**: Record under solid waste supply side attributed to Households and relevant coastal industries (ISIC 55-56, ISIC 37), disaggregated by coastal drainage basin where feasible.

¶42 **Example data pathway 3: Vessel emissions (CO2, SOx, NOx)**

1. ¶43 **Activity data**: Obtain fuel consumption data for vessels operating in national waters from one or more of: (a) MARPOL Annex VI fuel oil consumption data collection (mandatory for ships ≥5,000 GT); (b) AIS-derived engine hours combined with vessel-specific engine power and fuel consumption rates; (c) port authority bunkering records.
2. ¶44 **Boundary decision**: Decide whether the account uses the territorial boundary (all emissions within the EEZ, regardless of vessel flag) or the production-based boundary (all emissions by resident vessel operators, regardless of location). Document the choice and apply it consistently to both supply and use sides of Table 1 (see Section 3.5.2).
3. ¶45 **Emission factors**: Apply IMO Tier II emission factors by fuel type and vessel category (from the IMO Fourth Greenhouse Gas Study 2020)[46] to fuel consumption data to derive CO2, SOx, and NOx in tonnes.

DRAFT

4. ¶46 **Supply attribution**: Attribute to Shipping (ISIC 50) — Water transport, disaggregating between international and domestic voyages where possible.
5. ¶47 **Use side**: CO2 to Atmosphere use column; SOx and NOx to Atmosphere use column (with supplementary atmospheric deposition estimate in Table M1 if desired).
6. ¶48 **Account entry**: Record in Table 1, Air emissions rows, with a metadata note on boundary choice and data source.

¶49 Quality assurance considerations for residual flow accounts are addressed in TG-0.7 Quality Assurance.

5. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

6. References

1. ¶1 United Nations et al. (2014). *System of Environmental-Economic Accounting 2012 — Central Framework*. New York: United Nations.
2. ¶2 SEEA CF, Chapter III, Section 3.2, paragraphs 3.17-3.40.
3. ¶3 SEEA CF, paragraph 2.92 and 3.73.
4. ¶4 SEEA CF, paragraphs 3.88-3.95.
5. ¶5 SEEA CF, paragraph 3.92.
6. ¶6 SEEA CF, paragraphs 3.260-3.267.
7. ¶7 UN Statistics Division. SDG Indicator 14.1.1: Index of coastal eutrophication and floating plastic debris density.
8. ¶8 FAO and UNSD (2020). *System of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries (SEEA AFF)*. Section 4.5 on nutrient flow accounts.
9. ¶9 GESAMP (2019). *Guidelines for the monitoring and assessment of plastic litter in the ocean*. GESAMP Reports and Studies No. 99 (eds. Kershaw, Turra & Galgani). The primary microplastics assessment is GESAMP Reports and Studies No. 90 (2016).
0. ¶10 SEEA Technical Note: Water Accounting (2017), Section 2.1.4 on water emissions.
1. ¶11 SEEA CF, paragraph 3.91.
2. ¶12 SEEA Technical Note: Air Emissions Accounting (2016), paragraphs 17-20.
3. ¶13 SEEA Ecosystem Accounting (2021), Chapter 13 on thematic accounts, particularly Section 13.4 on climate change, including Figure 13.1 on the carbon cycle.
4. ¶14 Adapted from SEEA Ecosystem Accounting (2021), Figure 13.1: Main components of the carbon cycle.
5. ¶15 International Maritime Organization. International Convention for the Prevention of Pollution from Ships (MARPOL).
6. ¶16 IMO Ballast Water Management Convention (2004, in force 2017). D-2 standard specifies biological treatment requirements for ballast water discharge.
7. ¶17 SEEA CF, paragraphs 3.268-3.278.
8. ¶18 GESAMP (2019). *Guidelines for the monitoring and assessment of plastic litter in the ocean*. GESAMP Reports and Studies No. 99 (eds. Kershaw, Turra & Galgani).
9. ¶19 UN Statistics Division. SDG Target 14.1 and Indicator 14.1.1.
0. ¶20 TNFD (2023). *Recommendations of the Taskforce on Nature-related Financial Disclosures*, Metric C2.3: Plastic pollution.
1. ¶21 UNWTO and UNSD (2023). *Statistical Framework for Measuring the Sustainability of Tourism (SF-MST)*. Section 4.2.3 on solid waste accounting.
2. ¶22 Jambeck, J.R. et al. (2015). Plastic waste inputs from land into the ocean. *Science*, 347(6223): 768-771.
3. ¶23 Kaza, S. et al. (2018). *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*. Washington DC: World Bank. ISBN 9781464813290.
4. ¶24 UNEP (2024). *Global Waste Management Outlook 2024*. Nairobi: United Nations Environment Programme.
5. ¶25 FAO (2019). *Voluntary Guidelines on the Marking of Fishing Gear*. Rome: Food and Agriculture Organization of the United Nations. Adopted by COFI 33rd session, July 2018.
6. ¶26 Richardson, K. et al. (2019). Estimates of fishing gear loss rates at a global scale: a literature review and meta-analysis. *Fish and Fisheries*. doi: 10.1111/faf.12407.
7. ¶27 SEEA CF, Table 3.1: General physical supply and use table (Chapter III, paragraphs 3.17-3.40), with residual flows defined in paragraphs 3.73-3.87.

DRAFT

8. ¶28 United Nations (2008). *International Standard Industrial Classification of All Economic Activities, Revision 4*. Statistical Papers Series M No. 4/Rev.4.
9. ¶29 SEEA CF, paragraphs 3.260–3.267 (water emissions) and 3.268–3.277 (solid waste).
0. ¶30 SEEA Technical Note: Air Emissions Accounting (2016), paragraphs 25–27 on residence principle for transport emissions.
1. ¶31 SEEA Applications and Extensions, Chapter 4 on input-output analysis and consumption-based accounts.
2. ¶32 GOAP Technical Guidance on Ocean Accounts (2024). The drainage basin approach to spatial attribution draws on the SEEA CF combined presentations principles (paragraphs 2.80–2.84, which note the potential for regional disaggregation) and the spatial frameworks discussed in TG-3.1 Asset Accounts and TG-0.3 Spatial and Temporal Frameworks.
3. ¶33 SEEA CF, paragraphs 2.80–2.84 on combined presentations (which note the potential for regional disaggregation), and SEEA Applications and Extensions, Chapter 5 on sub-national and spatial analysis.
4. ¶34 Mayorga, E. et al. (2010). Global Nutrient Export from WaterSheds 2 (NEWS 2): Model development and implementation. *Environmental Modelling & Software*, 25(7): 837–853.
5. ¶35 SEEA Ecosystem Accounting (2021), Chapter 5 on ecosystem condition. See also Appendix A3 (paragraphs A3.27–A3.28) on marine-specific pressures including noise and habitat disturbance.
6. ¶36 SEEA Ecosystem Accounting (2021), Appendix A3 (paragraphs A3.27–A3.28) on marine ecosystem pressures including noise; and Chapter 5 on ecosystem condition assessment.
7. ¶37 Classification of Environmental Protection Activities and Expenditure (CEPA), Class 5: Noise and vibration abatement.
8. ¶38 IMO MEPC.1/Circ.833 (2014). Guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life. Revised guidelines adopted 2023.
9. ¶39 Longcore, T. and Rich, C. (2004). Ecological light pollution. *Frontiers in Ecology and the Environment*, 2(4): 191–198.
0. ¶40 SEEA CF, Chapter VI on integrating and presenting the accounts.
1. ¶41 United Nations et al. (2025). *System of National Accounts 2025*, Chapter 6 on gross value added at basic prices.
2. ¶42 NCAVES & MAIA (2022). *Monetary Valuation of Ecosystem Services and Assets for Ecosystem Accounting: Interim Version, 1st Edition*. United Nations Statistics Division. The interim guidance compiled under the NCAVES and MAIA projects synthesises valuation methods for SEEA EA implementation.
3. ¶43 NCAVES & MAIA (2022), Chapter 2. The distinction between exchange values (consistent with the SNA) and welfare values (including consumer surplus and non-use values) is foundational, and the simulated exchange value method is the recommended bridge where only stated-preference data exist.
4. ¶44 NCAVES & MAIA (2022), Chapter 3; SEEA Valuation Guidelines paras 973–987. The validity conditions for replacement cost and avoided damage cost methods include equivalence of service, least-cost alternative, and demonstrated demand or willingness to bear the cost.
5. ¶45 NCAVES & MAIA (2022), Chapter 4 (global climate regulation). The SEEA EA recommends ETS prices or marginal abatement cost estimates aligned with national emissions commitments as exchange-value-consistent carbon prices. The social cost of carbon is a welfare measure used in policy appraisal rather than an accounting price.
6. ¶46 IMO (2020). *Fourth IMO Greenhouse Gas Study 2020*. London: International Maritime Organization.

DRAFT

Social Accounts

Compiles social accounts for ocean accounting: systematically recording indicators relating to the contributions of ocean resources to human wellbeing.

Version	0.6.3	**Status**	Draft	**Stability**	Emerging
Last updated	September 2026	**Responsible officer**	Dr Rebecca Shellock		

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

CONTENTS

1. Outcome 3
2. Requirements 4
3. Guidance Material 5
3.1 Problem statement 5
3.2 What are Social Accounts? 6
3.3 Core principles: stocks and flows 11
3.4 Legitimacy, knowledge systems and co-design 20
3.5 Decision Use-Cases for Social Accounts 21
3.6 Wellbeing Indicators 23
3.7 Equity and Distribution 28
3.8 Vulnerability and Resilience 30
3.9 Qualitative Approaches 31
4. Compilation Procedure 33
4.1 Step-by-step compilation process 33
4.2 Data sources 37
4.3 Integration with other accounts 38
4.4 Challenges and limitations 38
4.5 Worked Example: Community Dependency and Distributional Analysis 39
5. Uncertainties and Risks 42
6. Acknowledgements 45
7. References 45
Footnotes 47

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Social Accounts (2026) (GOAP Technical Guidance TG-3.5 v0.3). GOAP Secretariat. https://guidance.oceanaccounts.org/drivers/social-3/3-5-social-accounts/

© 2026 Global Ocean Accounts Partnership. CC BY 4.0

OUTCOME

Upon completing this circular, readers will be equipped to:

- Understand the structure of the social domain of the Ocean Accounts Framework, which comprises two components: (i) Social Accounts and (ii) Governance Accounts and articulate the distinct role of each within that domain.
- Identify the key social dimensions of the human-ocean relationship that can be captured within a structured accounting framework, including dimensions that are typically invisible to conventional economic measures.
- Differentiate between stocks and flows, understand the theoretical basis for organising social phenomena within this architecture, and recognise its implications for how social data is collected, interpreted, and used.
- Understand how Social Accounts can be used to compile and interpret data on equity, inclusivity, and cultural values in ways that are interoperable with national accounts, the System of Environmental-Economic Accounting (SEEA), and other Ocean Accounts, thereby informing more credible, legitimate, and accurate policy decisions for a sustainable ocean.

The 2025 System of National Accounts recognizes that national accounts contribute to measuring wellbeing and sustainability beyond GDP, including through thematic and extended accounts for labour, human capital, and household distributional analysis. This Circular applies that broader perspective to ocean-specific contexts, through the social domain of Ocean Accounts. This circular establishes the conceptual framework for the Social domain of the Ocean Accounts Framework, referred to throughout as Social Accounts. This circular establishes the conceptual framework for the social domain of the Ocean Accounts Framework. The social domain comprises two components: Social Accounts, which capture the social, cultural, and equity dimensions of human-ocean relationships, and Governance Accounts, which capture the institutional structures, governance frameworks, and management arrangements through which ocean and coastal environments are governed. Both components are nested within the social domain and are treated in this guidance as complementary and interoperable parts of a single analytical structure. This circular focuses primarily on Social Accounts while introducing the two-component architecture of the social domain that subsequent guidance on Governance Accounts will build upon. Governance Accounts are addressed in detail in TG 3.7. It does so in recognition of a well-documented gap in how ocean systems are currently measured and governed.

The economic and environmental accounting frameworks that national statistical systems compile capture much of what the ocean produces in monetary terms: the value of fish catch, the output of shipping and coastal tourism, ecosystem extent, and the condition of marine assets. What they do not capture in any systematic and interoperable way is the social dimension of human-ocean relationships: the contributions that go uncounted, the dependencies that go unrecognised, and the inequities that go unnamed. Women's fish processing, community stewardship of nearshore reefs, informal gleaning, subsistence fishing, and the intergenerational transmission of marine knowledge are among the forms of activity and knowledge that conventional accounts render invisible. The communities that depend most directly on the ocean are frequently those most vulnerable to its degradation, yet they often bear the highest environmental and social costs while the economic gains from ocean resource use flow elsewhere. Social Accounts are designed to make these dimensions visible within a framework that is coherent, replicable, and interoperable with national statistical systems, creating the conditions for evidence-based, equitable, and inclusive ocean governance.

Social Accounts and Governance Accounts together constitute the social domain of the Ocean Accounts Framework, complementing the economic accounts described in TG-3.3 Economic Activity Relevant to the Ocean by extending measurement beyond monetary values to encompass the broader contributions of the ocean to quality of life. The social domain as a whole supports policy analysis for SDG 1 (No Poverty), SDG 8 (Decent Work and Economic Growth), SDG 10 (Reduced Inequalities), and SDG 14 (Life Below Water), particularly target 14.7 which calls for increasing "the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources". The classification of ocean industries that underpins Social Accounts employment measurement is established in TG-3.3 Economic Activity Relevant to the Ocean, which provides standardized industry definitions aligned with ISIC and CPC. This ensures consistency between the social accounts compiled under this Circular and the economic accounts compiled under TG-3.3.

DRAFT

1. Outcome

¶1 Upon completing this circular, readers will be equipped to:

- ¶2 Understand the structure of the social domain of the Ocean Accounts Framework, which comprises two components: (i) Social Accounts and (ii) Governance Accounts and articulate the distinct role of each within that domain.
- ¶3 Identify the key social dimensions of the human-ocean relationship that can be captured within a structured accounting framework, including dimensions that are typically invisible to conventional economic measures.
- ¶4 Differentiate between stocks and flows, understand the theoretical basis for organising social phenomena within this architecture, and recognise its implications for how social data is collected, interpreted, and used.
- ¶5 Understand how Social Accounts can be used to compile and interpret data on equity, inclusivity, and cultural values in ways that are interoperable with national accounts, the System of Environmental-Economic Accounting (SEEA), and other Ocean Accounts, thereby informing more credible, legitimate, and accurate policy decisions for a sustainable ocean.

¶6 The 2025 System of National Accounts recognizes that national accounts contribute to measuring wellbeing and sustainability beyond GDP, including through thematic and extended accounts for labour, human capital, and household distributional analysis. This Circular applies that broader perspective to ocean-specific contexts, through the social domain of Ocean Accounts. This circular establishes the conceptual framework for the Social domain of the Ocean Accounts Framework, referred to throughout as Social Accounts. This circular establishes the conceptual framework for the social domain of the Ocean Accounts Framework. The social domain comprises two components: Social Accounts, which capture the social, cultural, and equity dimensions of human-ocean relationships, and Governance Accounts, which capture the institutional structures, governance frameworks, and management arrangements through which ocean and coastal environments are governed. Both components are nested within the social domain and are treated in this guidance as complementary and interoperable parts of a single analytical structure. This circular focuses primarily on Social Accounts while introducing the two-component architecture of the social domain that subsequent guidance on Governance Accounts will build upon. Governance Accounts are addressed in detail in TG 3.7. It does so in recognition of a well-documented gap in how ocean systems are currently measured and governed.

DRAFT

¶7 The economic and environmental accounting frameworks that national statistical systems compile capture much of what the ocean produces in monetary terms: the value of fish catch, the output of shipping and coastal tourism, ecosystem extent, and the condition of marine assets. What they do not capture in any systematic and interoperable way is the social dimension of human-ocean relationships: the contributions that go uncounted, the dependencies that go unrecognised, and the inequities that go unnamed. Women's fish processing, community stewardship of nearshore reefs, informal gleaning, subsistence fishing, and the intergenerational transmission of marine knowledge are among the forms of activity and knowledge that conventional accounts render invisible. The communities that depend most directly on the ocean are frequently those most vulnerable to its degradation, yet they often bear the highest environmental and social costs while the economic gains from ocean resource use flow elsewhere. Social Accounts are designed to make these dimensions visible within a framework that is coherent, replicable, and interoperable with national statistical systems, creating the conditions for evidence-based, equitable, and inclusive ocean governance.

¶8 Social Accounts and Governance Accounts together constitute the social domain of the Ocean Accounts Framework, complementing the economic accounts described in TG-3.3 Economic Activity Relevant to the Ocean by extending measurement beyond monetary values to encompass

the broader contributions of the ocean to quality of life. The social domain as a whole supports policy analysis for SDG 1 (No Poverty), SDG 8 (Decent Work and Economic Growth), SDG 10 (Reduced Inequalities), and SDG 14 (Life Below Water), particularly target 14.7 which calls for increasing "the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources". The classification of ocean industries that underpins Social Accounts employment measurement is established in TG-3.3 Economic Activity Relevant to the Ocean, which provides standardized industry definitions aligned with ISIC and CPC. This ensures consistency between the social accounts compiled under this Circular and the economic accounts compiled under TG-3.3.

2. Requirements

¶1 This circular builds on conceptual and statistical foundations that are essential reading before engaging with the social domain of Ocean Accounts and its two components (Social Accounts and Governance Accounts). Readers who are new to ocean accounting are strongly encouraged to begin with the GOAP foundational circulars listed below, which introduce the Ocean Accounts Framework and the international statistical standards that govern its application. Readers with existing familiarity with the System of National Accounts (SNA) or the System of Environmental-Economic Accounting (SEEA) will find that much of the theoretical reasoning in this circular depends on understanding what those frameworks do, what they do not do, and where the social domain extends or complements their scope. The prerequisites are not merely technical background. They are the conceptual context within which the argument of this circular makes sense. Engaging with them first will make it significantly easier to follow the theoretical reasoning about why social phenomena require distinct treatment within an accounting framework and what it means for Social Accounts and Governance Accounts to be interoperable with existing national and environmental-economic accounts.

¶2 The following provide the necessary foundation for this circular:

- ¶3 **System of National Accounts (SNA 2025).** The international standard for compiling national accounts, maintained by the United Nations Statistics Division. The 2025 revision explicitly broadens the framework's scope to encompass wellbeing and sustainability[1], providing the mandate and conceptual architecture within which Social Accounts sit. Available at: https://unstats.un.org/unsd/nationalaccount/sna.asp (https://unstats.un.org/unsd/nationalaccount/sna.asp)
- ¶4 **System of Environmental-Economic Accounting — Central Framework (SEEA-CF) and Ecosystem Accounting (SEEA-EA).** The international standards for integrating environmental data into economic accounts. The SEEA's stocks-and-flows architecture and its treatment of physical and monetary asset accounts provide the direct structural analogue for Social Accounts. Available at: https://seea.un.org (https://seea.un.org)
- ¶5 **GOAP Foundational Concepts (Circular 0.1).** Introduces the fundamental principles of Ocean Accounts, including their purpose, scope, and relationship to the SNA and SEEA. Available at: https://www.oceanaccounts.org/technical-guidance (https://www.oceanaccounts.org/technical-guidance)
- ¶6 **Data and Statistical Standards (Circular 0.2).** Covers basic data compilation, classification systems, and the importance of adhering to statistical standards in ocean accounting contexts. Available at: https://www.oceanaccounts.org/technical-guidance (https://www.oceanaccounts.org/technical-guidance)

¶7 This circular does not provide step-by-step instruction in the mechanics of data collection or the compilation of SNA or SEEA accounts; those are addressed in the operational circulars that follow in this series. What it provides instead is the conceptual bridge connecting the social domain, comprising Social Accounts and Governance Accounts to the established accounting frameworks

DRAFT

described above. Understanding why the social domain is structured the way it is and what theoretical claims underpin that structure, depends on understanding the broader frameworks within which it is designed to operate. This document is the conceptual entry point. It maps the theoretical terrain on which all subsequent, more operational guidance stands, and equips readers to engage with that guidance with genuine understanding of its foundations rather than as a set of unexplained procedures. Readers who complete this circular and the operational guidance that follows will be positioned to design, compile, and advocate for the social domain within national statistical systems in ways that are theoretically coherent and practically defensible.

3. Guidance Material

¶1 **Scope**

¶2 TG-3.5 owns the social account tables for the ocean domain: social assets and conditions, social activities, employment and its disaggregations, distributional and dependency measures, and the classifications those rest on. Social accounts sit outside the SEEA table set and are an Ocean Accounts extension, so this Circular is also where their boundary against the SNA household sector is drawn. It cross-refers to **TG-3.12** for household and beneficiary accounting, **TG-3.13** for gender and social inclusion, **TG-3.6** for traditional knowledge, **TG-2.3** for the indicators derived from these accounts, and **TG-4.2** for the household survey instruments that populate them.

3.1 Problem statement

¶1 The urgency of measuring societal progress beyond conventional economic metrics such as Gross Domestic Product (GDP) is now firmly established in international policy and statistical discourse [1, 2]. GDP captures the output of market-based economic activity and remains a critical measure for economic governance, but it does not represent the full dimensions of human well-being or the sustainability of the capital stocks on which communities depend. This recognition has driven the global beyond-GDP movement and has prompted the international statistical community to undertake a significant evolution of its core frameworks. The 2025 revision of the System of National Accounts (SNA 2025) explicitly broadens the scope of the national accounts to better inform on well-being and sustainability [3]. This is not a peripheral adjustment, it is a central feature of the new standard. It includes thematic and extended accounts for areas directly relevant to the social domain of Ocean Accounts, including unpaid household service work, health, and education, and it describes how well-being data can be organised using accounting approaches that extend beyond the integrated framework of national accounts [3]. This provides a clear and authoritative mandate for developing the social domain, comprising Social Accounts and Governance Accounts, as a legitimate core component of the Ocean Accounts Framework. The Ocean Accounts Framework integrates information across economic, environmental, and social domains to enable coherent measurement of progress toward sustainable ocean development [6]. It draws on both the System of Environmental-Economic Accounting (SEEA) and the SNA and is appropriately understood as a framework that integrates economic, environmental, and social dimensions, not as either alone [20, 21].

¶2 Despite the progress these frameworks represent, the social domain of ocean accounting has lagged significantly behind the economic and environmental domains, and this lag has consequences for communities whose lives and livelihoods depend most directly on the sea. Current frameworks do not capture in any systematic way the non-economic contributions of ocean ecosystems to human communities: livelihoods, nutritional security, social protection, disaster resilience, and the cultural connections that coastal peoples hold with the ocean. The challenge is not only the fragmentation of social data across disparate government ministries, research institutions, and non-governmental organisations, each using different definitions and methodologies [12, 13]. In many settings, particularly in low- and middle-income countries and remote coastal regions, there is simply no data to integrate: the systems for collecting, standardising, and maintaining social information about ocean-dependent communities have not been funded or built. This more fundamental

DRAFT

problem demands a framework that can accommodate partial data, support data development, and remain meaningful even where the information base is thin. The ocean economy, meaning the set of economic and social activities related to ocean resources and spaces, produces significant wealth, but the measurement of that wealth reflects only what the formal economy transacts. Women's fish processing, community stewardship of nearshore reefs, informal gleaning, subsistence fishing, and the intergenerational transmission of marine knowledge fall outside the production boundary of the SNA. Their absence from the accounts does not mean they are absent from human lives. It means they are invisible to governance.

¶3 The invisibility of these contributions is not evenly distributed. The environmental justice literature has established that environmental quality and environmental burden are socially distributed, with more marginalised communities experiencing greater exposure to environmental harm [10, 11]. In the context of the ocean, this inequity extends from the distribution of burdens to the distribution of benefits. The economic and social gains from ocean resources and coastal development frequently flow to stakeholders and regions far removed from the communities that bear the associated environmental and social costs [12, 13]. These distributional asymmetries are not merely geographic or economic: they are intersectional. Gender, age, ethnicity, indigeneity, and disability all shape who benefits, who bears costs, and whose labour and knowledge goes uncounted. Women perform the majority of fish processing, gleaning, and unpaid provisioning labour in many ocean-dependent communities, yet this work is systematically excluded from national statistics [17]. Indigenous Peoples and Local Communities hold deep and constitutive relationships with ocean territories, yet their management contributions and knowledge systems remain largely unrecognised in formal accounting frameworks [24, 21]. Understanding the relationship between natural assets and social deprivation, and between ocean governance and distributional outcomes, is a precondition for policies that are equitable and legitimate. Social Accounts are designed to enable this analysis by making visible the dimensions of human-ocean relationships that conventional accounts render absent. Together with Governance Accounts, they form the social domain through which the Ocean Accounts Framework can track both the lived realities of ocean-dependent communities and the institutional conditions that shape those realities.

¶4 The case for Social Accounts is further strengthened by the accelerating effects of climate change on coastal communities and ocean systems. Environmental change does not affect all communities equally. Coastal communities, particularly those in Small Island Developing States and low-income coastal contexts, face compound risks: loss of marine protein sources, disruption of traditional livelihood systems, damage to cultural and sacred sites, and the loss of productive hours attributable to environmental degradation [17]. Vulnerability to these impacts is not simply a function of exposure: it is shaped by adaptive capacity, which is itself a social condition that Social Accounts must track. Communities with stronger social capital, secure access to resources, and functioning governance institutions are better placed to manage environmental shocks and recover from them. Social Accounts are therefore not only a tool for measuring current human-ocean relationships but a framework for tracking how those relationships change under pressure, and for identifying the communities whose adaptive capacity is most at risk. This temporal and distributional dimension is essential if the social domain is to support just transitions toward sustainable ocean use, ensuring that the human costs of governance transformations are documented, acknowledged, and addressed rather than absorbed invisibly by those least able to bear them. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services Nature's Contributions to People (NCP) framework provides a complementary theoretical lens, recognising that contributions from nature to people are inherently relational and culturally contingent, and that their value cannot be assessed independently of the communities that experience them [23].

3.2 What are Social Accounts?

¶1 The social domain of the Ocean Accounts Framework comprises two components: Social Accounts and Governance Accounts. Social Accounts are the component of the social domain that

DRAFT

focuses on the social, cultural, and equity dimensions of human-ocean relationships. Governance Accounts are the component that focuses on the institutional structures, governance arrangements, and management frameworks that shape how ocean and coastal environments are governed; they are addressed in detail in Circular 3.7. This section defines Social Accounts and their scope; the relationship between the two components is addressed in Section 3.3.1 under institutional capital.

¶2 Social Accounts are defined, within the Ocean Accounts Framework, as the structured compilation of social, cultural, and equity data on human-ocean relationships, organised within an integrated framework that is interoperable with the System of National Accounts (SNA), the System of Environmental-Economic Accounting (SEEA), and the broader Ocean Accounts Framework [12, 13, 14]. This definition marks an evolution from the long-standing practice of compiling social statistics, which are quantitative measures of societal conditions, behaviours, and trends produced across government agencies, research institutions, and non-governmental organisations. Social statistics are indispensable, but they have an inherent limitation: they exist as individual data points and collections of metrics, each scoped to the needs of the institution that produces them, using definitions and methodologies that may not be consistent across sectors or comparable over time. The move from social statistics to Social Accounts is not a critique of social statistics but a maturation of practice. Social Accounting is the systematic process of capturing, analysing, and reporting social information within an integrated accounting framework. The output of this process — the Social Account — connects individual statistics into a coherent whole that reveals relationships between different social dimensions and links them explicitly to the economic and environmental domains [13]. It moves beyond a dashboard of indicators to create a dynamic, integrated system capable of explaining change, tracking distributional outcomes, and informing adaptive governance.

¶3 For the social domain to fulfil its potential within ocean accounting, both Social Accounts and Governance Accounts must be designed for replicability and sustained over time. One-off data collection efforts, while valuable for establishing baseline understanding, do not provide the consistent, comparable time-series data required for effective policy monitoring and adaptive management. Each component must therefore be embedded within ongoing national statistical programmes, owned by statistical agencies or equivalent institutions with the mandate and capacity for regular data production. This institutional anchoring ensures methodological consistency, quality assurance, and the long-term continuity necessary for tracking changes in human-ocean relationships across generations. The social domain should serve government agencies, research institutions, non-governmental organisations, and rightsholders, including Indigenous Peoples and other communities with rights-based relationships to ocean resources and territories, who have both a direct interest in the data and a legitimate claim over how it is produced and used. The ambition to encompass economic, environmental, and social domains in a coherent measurement framework [1] requires a social architecture that is as rigorous and as institutionally anchored as its economic and environmental counterparts.

¶4 Social Accounts depart from several earlier uses of the terms “social accounting” and “social accounts” that originate in different fields and serve different purposes. The following table (Table 2) sets out what falls within and outside the scope of this framework across ten dimensions: (i) position within the Ocean Accounts framework; (ii) scope and structure of data captured; (iii) relationship to economic value; (iv) level and spatial scale of analysis; (v) integration across domains; (vi) treatment of knowledge systems; (vii) temporal design; (viii) methods; (ix) populations covered; and (x) the basis on which legitimacy is claimed.

¶5 **Table 2:** What Social Accounts are and what they are not.

DRAFT

Dimension	Social Accounts are…	Social Accounts are not…
Framework position	One of two components of the social domain of the Ocean Accounts Framework — the other being Governance Accounts. Social Accounts are an extended account nested within the Ocean Accounts framework, built on the national accounting paradigm and linked to and interoperable with the SNA 2025 and SEEA. The SNA 2025 provides explicit mandate and authoritative basis for Social Accounts as a legitimate, standardised core account, particularly through its thematic extensions on unpaid household work, health, and education. Governance Accounts sit alongside Social Accounts as the second component of the social domain, both are subordinate to the social domain rather than parallel to it.	A standalone framework separate from Ocean Accounts or national accounting systems, or a competing parallel to SEEA Environmental-Economic Accounts. Social Accounts are also not the entirety of the social domain, that domain encompasses Governance Accounts as well.
Scope and structure	A framework that captures the social, cultural, and equity dimensions of the human-ocean relationship through two entry points: social assets and conditions (stocks representing the state of the social environment at a point in time) and social activities (flows that occur largely outside the SNA production boundary, including unpaid labour, community stewardship, and customary practices). Organised around the dual concepts of stocks and flows — directly analogous to SEEA architectural principles with Supply-Use Tables and Input-Output Tables providing the core mechanisms for capturing relationships between social, economic, and environmental domains. This stock-flow structure is what makes it possible to explain change over time rather than merely describe a snapshot.	Limited to what formal data systems already collect. Social Accounts are also not a list of standalone indicators or a database of social statistics, without a stock-flow structure, it is impossible to explain change over time rather than merely describe a snapshot. Nor are they a Social Accounting Matrix (SAM). SAMs deal only with economic transactions and socio-economic indicators, making them unable to capture the cultural, non-market, or equity dimensions that are central to Social Accounts.
Relation to economic value	Able to capture non-monetary social flows, including unpaid household labour, informal fish processing, community care, and customary practices, that are invisible in GDP and unrepresented in conventional economic accounts.	Focused on the monetisation or economic valuation of ecosystem services. Social Accounts deliberately diverge from that debate to avoid duplicating SEEA Environmental-Economic Accounts and to sidestep the value-concept disputes that have historically slowed progress in environmental accounting.
Accounting structure	Organised around the dual concepts of stocks (social assets and conditions at a point in time) and flows (social activities during an accounting period), directly analogous to SEEA architectural principles. Supply-Use Tables and Input-Output Tables provide the core mechanisms for capturing relationships between social, economic, and environmental domains.	A list of standalone indicators or a database of social statistics. The stock-flow accounting structure is what distinguishes Social Accounts from conventional social data compilation and makes it possible to explain change over time rather than merely describe a snapshot.

DRAFT

Dimension	Social Accounts are…	Social Accounts are not…
Level of analysis	Anchored in national statistical frameworks and designed for institutional ownership by national statistical agencies. While national-level totals are the baseline output, Social Accounts can be compiled at sub-national scales — district, regional, or community, where underlying data allow. The achievable scale is determined by data availability and spatial granularity, not fixed by design. In practice, different dimensions within the same account may operate at different scales.	Exclusively national or exclusively local. Sub-national analysis requires that underlying datasets can be reliably attributed to smaller geographic units. Scale is a function of data capacity. Social Accounts are also not corporate or critical accounting, they are not involved in CSR reporting, organisational auditing, or stakeholder transparency exercises, which address organisational-level accountability rather than national statistical systems.
Integration	An integrated system that reveals relationships between social dimensions and explicitly links them to economic and environmental domains through common accounting structures, supporting integrated analysis of trade-offs and synergies across all three domains. This is a step toward a "system of systems" that encompasses the environmental, societal, and economic domains in a coherent measurement framework.	A dashboard of social statistics. Social Accounts go beyond fragmented indicators residing across different ministries using inconsistent definitions, creating instead an internally consistent and cross-domain accounting framework.
Knowledge systems	Inclusive of Indigenous, traditional, and local knowledge as epistemically legitimate sources, not merely illustrative data points. The framework recognises that traditional knowledge systems may not separate people and nature as Western accounting frameworks do, and that qualitative narrative approaches are structurally essential for capturing cultural identity, spiritual connection, and relational values that cannot be reduced to numerical metrics alone.	Limited to formal statistical sources or purely quantitative methods. The weaving together of Indigenous and local knowledge with formal data systems, rather than subsuming one into the other, preserves the integrity of distinct knowledge systems. The language of weaving is deliberate, it signals a relationship of mutual respect, not absorption.
Spatial design	Spatially explicit, anchored to Basic Spatial Units (BSUs) differentiated into terrestrial, coastal, and marine zones. Social data are mapped to the same geographic framework used for economic and environmental accounts, enabling cross-domain analysis. Where social datasets carry geographic identifiers attributable to BSUs or overlying administrative units, accounts can be compiled at sub-national scale. In lower-data environments, a national account is built first and spatial disaggregation introduced iteratively as data capacity grows.	A non-spatial aggregation of national totals, nor a framework that requires fine-grained spatial data before it can begin. Spatial disaggregation is a core design principle, but the degree achievable depends on data resolution. The direction of travel is always toward greater spatial precision; the starting point is determined by what exists.
Temporal design	Designed for longitudinal, repeated measurement, embedded in ongoing national statistical programmes, enabling the comparable time-series data required for policy monitoring and adaptive management. Methodological consistency over time is a structural requirement, and Social Accounts must be owned by statistical agencies with the mandate and capacity for regular data production.	One-off data collection efforts or standalone reports. While baseline studies have value, Social Accounts require institutional anchoring within national statistical systems to track changes in human-ocean relationships across generations and to support adaptive governance over time.

DRAFT

Dimension	Social Accounts are…	Social Accounts are not…
Methods	Mixed-methods in design, combining quantitative indicators with structured qualitative narrative information. Both approaches are treated as equally legitimate, not as primary and supplementary. This is particularly important when working with Indigenous and local communities whose knowledge systems may not align with quantification frameworks, and for dimensions such as cultural identity, spiritual connection, and sense of place.	Purely quantitative. A framework that discards qualitative information produces an incomplete and potentially distorting picture of the human-ocean relationship. Narrative elements are not supplementary to the accounts but essential for ensuring they are salient and legitimate for the communities they are meant to serve.
Population covered	Attentive to the realities of people who are absent from conventional economic statistics, including women engaged in unpaid fish processing, subsistence fishers, informal workers, Indigenous communities, and others rendered invisible by the SNA production boundary. Social Accounts apply an intersectional lens, disaggregating data across gender, age, ethnicity, disability, and geography rather than treating communities as monolithic.	Concerned only with formally employed or economically active populations captured by existing labour force and industry surveys. Social Accounts exist precisely because those surveys systematically exclude the people most directly dependent on and most affected by ocean governance decisions.
Process legitimacy	Dependent on how they are built, not only on what they contain. Legitimacy requires co-design with the communities whose realities are being counted, genuine participation in decisions about what is measured and how, and accountability to those communities in how results are used. A credible, legitimate, and salient account is one communities can recognise and engage with.	Legitimate solely by virtue of technical rigour or alignment with international standards. A technically sound account that communities cannot recognise, engage with, or trust is not a good account. Legitimacy is earned through process and product together.

¶6 The integration of social, cultural, and equity data within the Ocean Accounts Framework is made possible through three structural mechanisms. First, a spatial data framework uses Basic Spatial Units (BSUs) as its foundation, enabling social data to be mapped to marine and coastal areas with depth layers that accommodate the three-dimensional nature of ocean systems. Second, the integrated stocks-and-flows accounting structure captures both social capital and conditions at a point in time (see 3.3.1) and the social activities that generate and draw upon those stocks during an accounting period (see 3.3.2). Third, a multi-dimensional framework captures 17 types of social data relevant to stocks and flows, as set out in Appendix 1. These 17 data types are not a separate taxonomy alongside the stocks-and-flows architecture: they are its empirical content. The human, relational, institutional, and cultural capital categories each encompass several of these data types, and the flow categories similarly draw on multiple data types to describe social activity. Key dimensions that Social Accounts must explicitly capture include food security and nutritional dependence on marine protein; cultural and spiritual well-being encompassing traditional practices, sense of place, and intergenerational transmission of marine culture; and experienced environmental quality as perceived by communities, which may diverge substantially from ecosystem condition as measured in environmental accounts alone [8].

¶7 Social Accounts can be applied at multiple spatial scales, from household and community level to district, national, and transboundary scales, and these scales are hierarchically related rather than mutually exclusive. Sub-national data is particularly important for capturing the distributional dimensions of human-ocean relationships, since national-level aggregates can mask profound variation in outcomes across communities, regions, and social groups. For compilation purposes, the coastal population encompasses all households and communities whose livelihoods, food security, cultural practices, or physical safety are directly linked to the ocean, coastal zone, or marine resources — whether through residence, occupation, or cultural and spiritual connection. This definition is intentionally broad in order to include communities that may be geographically removed

DRAFT

from the shoreline but remain substantively ocean-dependent, including through seafood trade, cultural heritage, and customary stewardship.

¶8 The application of a stocks-and-flows architecture to social phenomena requires epistemological justification, because the move is not self-evident. Physical and monetary accounts organise assets and flows in ways that align naturally with measurable quantities; social reality is more complex, being constituted by relationships, meanings, power, and experience, none of which can be fully captured in any single accounting structure. The theoretical basis draws on three complementary arguments. First, the architecture enables structural comparability across domains, making it possible to identify and analyse relationships between social conditions, economic activity, and ecosystem health in ways that are not possible when the domains are measured within incompatible frameworks. Second, the architecture captures change over time: stocks represent the state of social conditions at a point in time, and flows represent the activities and events that alter those states, enabling analysis of how communities respond to environmental shocks, governance transitions, and structural change. Third, the architecture makes visible what is otherwise invisible. The decision to record unpaid household labour, community stewardship, and cultural practice as flows within an accounting framework is a deliberate epistemological choice: it asserts that these activities produce social value and that their omission from conventional accounts is a distortion of reality, not a neutral measurement decision. The architecture cannot capture everything about social life, and any adequate theoretical foundation must acknowledge this honestly. Social Accounts should be understood as a necessary but not sufficient tool for understanding human-ocean relationships. They create conditions for evidence-based governance; they do not replace the judgement, negotiation, and political will that governance requires.

¶9 A theoretically coherent treatment of Social Accounts must address the status of Indigenous, Traditional, and Local Knowledge (ITK) within the framework. The risk of a framework that incorporates ITK without attending to the terms of its inclusion is not merely methodological: it is a risk of epistemic and political harm. Indigenous knowledge systems are constituted by distinct ontologies, values, and governance structures. They are not data to be extracted and integrated into existing frameworks on those frameworks' terms. The appropriate language for this relationship is weaving rather than integrating: two or more distinct knowledge systems brought into productive relationships while preserving the integrity of each. In practice, Indigenous, Traditional, and Local Knowledge enters Social Accounts on the terms set by knowledge holders, under protocols of Free, Prior, and Informed Consent (FPIC), and subject to community-controlled data sovereignty arrangements [24, 21]. Data sovereignty encompasses the right to determine what data about their communities is collected, by whom, in what format, under what conditions of use, and with what protections against misuse or misrepresentation. This is particularly important because social data about vulnerable communities can carry safety risks if made publicly available without adequate safeguards. The body of Traditional Ecological Knowledge held by a community is a social stock, part of its cultural capital; the act of sharing that knowledge across generations or with others is a social flow. This is a distinction that is both theoretically important and practically necessary for correct classification within the stocks-and-flows framework.

DRAFT

3.3 Core principles: stocks and flows

¶1 Figure 0.1.3 in **TG-0.1 General Introduction to Ocean Accounts** presents the key conceptual components of the Ocean Accounts Framework, situating the social domain within a structured architecture that captures the full breadth of human-ocean relationships. Within this architecture, Social Accounts operate through two principal entry points: social assets and conditions, which function as stocks, and social activities, which function as flows. Together, these entry points constitute the analytical core of Social Accounts and determine how social data is collected, organised, and interpreted. They describe a dynamic and interconnected system for representing social reality over time. Governance Accounts, the second component of the social domain, draw on the same stocks-and-flows architecture applied to the institutional capital dimension described in Section

3.3.1. This architecture is drawn from the System of Environmental-Economic Accounting (SEEA) framework and its two principal components: the SEEA Central Framework [15] and the SEEA Ecosystem Accounting (SEEA-EA) [16]. The established SEEA methodologies for compiling physical and monetary asset accounts and supply-use tables offer rigorously tested conceptual structures that can be adapted to organise social data within the same accounting logic. By following the SEEA's architectural principles, Social Accounts achieve conceptual rigour and interoperability with the SNA and with environmental accounts. Within this architecture, stocks represent the state of social assets and conditions at a specific point in time, and flows represent the actions, activities, and events that create, transform, or draw upon those stocks during an accounting period. The relationship between stocks and flows is dynamic and bidirectional: social activities can build social capital over time, as when community-based fisheries management strengthens institutional governance and relational trust, or they can draw upon it, as when extended environmental disruption depletes community health and adaptive capacity. This bidirectional dynamic is not simply a feature of the architecture: it is a theoretical claim about how social systems function. Where the text says that flows "generate or draw upon" stocks, the direction of causation matters and must be specified for each activity: some activities build the stock base, others deplete it, and some do both depending on context. The architecture cannot fully represent the experiential, relational, and spiritual dimensions of human-ocean relationships, which is addressed through the qualitative and knowledge-system dimensions of Social Accounts described in Section 3.4.

¶2 The stocks-and-flows framework is designed to be dynamic rather than static, and it should be applied with contextual adaptation and reflexivity rather than as a fixed taxonomy. Different communities, jurisdictions, and governance contexts will organise and prioritise social data differently, and the framework must accommodate this variation without sacrificing the interoperability and comparability that give Social Accounts their analytical value. The framework should be reviewed and updated as understanding of human-ocean relationships evolves, as new data sources become available, and as communities and governance contexts change. The transition from the stocks sub-section (3.3.1) to the flows sub-section (3.3.2) reflects the logical relationship between the two parts of the framework: the stocks section describes the social assets and conditions that exist at a point in time and that enable or constrain social activities; the flows section describes those activities and how they in turn maintain, build, or deplete the stock base. Neither section is complete without the other, and the two accounts are designed to be read together as an integrated picture of social conditions and social dynamics.

DRAFT

3.3.1 Social assets and conditions (stocks)

¶1 Social assets and conditions are conceptualised as stocks within this framework, representing the state or level of particular social assets or conditions at a point in time. This is analogous to the treatment of individual environmental assets in the SEEA Central Framework [15] and produced and financial assets in the SNA [3]. The distinction between an asset and a condition is important. An asset is a stock that has productive capacity: it can generate flows of social services and activities over time. A condition describes the state of a social dimension that matters for well-being, including equity, health, and vulnerability, but may not directly generate flows in the same way. In practice, the line between assets and conditions is not always sharp, and the framework accommodates both without requiring strict separation in every case. Social assets and conditions are organised into four categories: human capital, relational capital, institutional capital, and cultural capital. This four-part typology is designed to be read alongside, rather than in competition with, the Five Capitals framework widely used in sustainability assessment and livelihoods analysis, which encompasses natural, human, social, manufactured, and financial capital. Physical and financial capitals are addressed in the economic accounts of the Ocean Accounts Framework (TG-3.3); the social domain focuses on the human, relational, institutional, and cultural dimensions that those accounts do not capture. This division of labour supports integration across frameworks rather than duplication. Note: GEDSI encompassing gender equity, disability, social inclusion, and the recognition of distinct

social groups is not a separate category: it is a design principle embedded across the entire architecture. Every stock indicator must be designed to enable disaggregation by gender (or "sex" if most appropriate), age group, ethnicity, indigeneity, disability status, and geographic location so that the accounts reveal distributional differences rather than erasing them through aggregation.

¶2 Human capital encompasses the knowledge, skills, health, and capabilities embodied in individuals and communities that enable interaction with the ocean and with coastal governance systems. This includes educational attainment, occupational skills, physical and mental health status, the level of community engagement in ocean-related activities, and the capacity to adapt to change. Adaptive capacity, understood following the Intergovernmental Panel on Climate Change (IPCC) as the ability of a system or its component parts to adjust to potential damage, take advantage of opportunities, or respond to consequences [24], is a critical dimension of human capital in the context of Social Accounts. The IPCC identifies four intersecting dimensions of vulnerability relevant to ocean-dependent communities: climate vulnerability, economic vulnerability, social vulnerability, and ecological vulnerability. Social Accounts must be designed to capture vulnerability across all four dimensions, recognising that communities often face multiple simultaneous pressures and that their capacity to cope depends on the depth of their social capital base. Assessment of vulnerability should be transparent about the assumptions involved in combining multiple dimensions, given that no composite vulnerability index has yet achieved international statistical endorsement.

¶3 Relational capital encompasses the networks, relationships, trust, and collective resources that connect coastal and ocean-dependent individuals and communities. These are the social conditions that enable economic and social activities to take place, including coordination in fisheries management, information sharing across communities, and mobilisation of collective action in response to environmental change or governance threats. Relational capital is analytically distinct from institutional capital in that it refers to the informal, social, and relational dimensions of community life: trust between households, kinship networks, reciprocal exchange relationships, and the horizontal ties that build solidarity and resilience. In practice, the boundary between relational and institutional capital is particularly difficult to maintain for Indigenous communities, where governance relationships are constituted through kinship, ceremony, and relationship with territory rather than through formal institutional structures. The framework acknowledges this boundary is porous and should not be applied in ways that fracture or misrepresent social realities that are not organised along these categories. The body of Traditional Ecological Knowledge held by a community is a stock of relational and cultural capital: it accumulates through generations, is held collectively, and is inseparable from the relationships and governance systems within which it lives. The act of sharing that knowledge is a social flow, described in Section 3.3.2, and these two dimensions of knowledge must be kept analytically distinct to avoid double-counting and to accurately represent the dynamics of knowledge loss and renewal.

¶4 Institutional capital encompasses the formal and informal rules, governance structures, and organisational systems that regulate human interactions with ocean and coastal environments and shape marine resource management decisions. This includes marine spatial planning frameworks, fisheries management agreements, legally recognised treaties, customary governance systems, maritime law enforcement arrangements, and the co-management agreements through which communities and government agencies share decision-making authority. Governance resilience, described by the IPCC as one of four resilience dimensions alongside ecological, economic, and social resilience, is a particularly important theoretical anchor for institutional capital: it describes the capacity of governance institutions to adapt, learn, and reorganise in the face of change [24]. The distribution of access rights to ocean resources is a form of institutional capital whose structure is constitutive of social equity. Whether communities hold secure and enforceable rights to fish, gather, navigate, and steward their traditional territories shapes their economic vulnerability, their political voice, and their capacity to participate in governance. This guidance takes a clear position on the relationship between governance and social accounting: governance is a substantive dimension of social life, and both Social Accounts and Governance Accounts sit nested within the

DRAFT

broader social domain of the Ocean Accounts Framework. Governance Accounts are therefore treated here as a distinct but subordinate account type within that domain, rather than as a parallel structure sitting alongside it. The conceptual and methodological framework for Governance Accounts is developed in detail in Circular 3.7.

¶5 Cultural capital encompasses the cultural heritage, shared identity, place-based attachment, creative practices, and knowledge systems that connect communities to the ocean across generations. It is a distinct fourth stock category because cultural dimensions of human-ocean relationships are not adequately captured within human, relational, or institutional capital alone. Cultural capital includes: the body of Indigenous and Traditional Ecological Knowledge held by a community and the practices through which it is transmitted; sense of place and the emotional, spiritual, and cultural meanings associated with particular marine territories and seascapes; intergenerational cultural practices including traditional navigation, boat building, ceremony, storytelling, and food preparation from the sea; and language and cultural expression associated with the ocean. The case for cultural capital as a stock in its own right rests on both theoretical and empirical grounds. Theoretically, cultural and knowledge systems are generative: communities with rich cultural capital have more diverse and resilient ways of understanding and responding to environmental change. Empirically, the loss of cultural capital through displacement, environmental degradation, suppression of traditional practices, or failure to transmit knowledge is among the most significant and least reversible consequences of ocean governance failures for coastal communities [8, 21]. Cultural capital indicators must attend particularly to the gendered dimensions of cultural transmission and the differential exposure to cultural loss across age groups, recognising that elders and youth occupy distinct and irreplaceable positions in the reproduction of cultural knowledge.

¶6 Social equity is formalised as a core social condition across this framework, not simply as an aspiration or an indicator sub-category. Equity describes the distributional state of a society: who holds rights, who has access, who has voice, and who has the power to influence decisions that affect their lives and communities. As a social condition, equity must be assessed across all four capital categories and across the temporal dimension of Social Accounts, asking not only whether current distribution is equitable but whether current ocean use is building or eroding the conditions for equity in future generations. Intergenerational distribution is a dimension of equity that existing accounts consistently underweight. Social Accounts must track how current patterns of ocean use, resource governance, and environmental change affect the social assets and conditions available to future generations, connecting the measurement of present stocks to long-term sustainability. The geography of equity also matters: coastal communities in remote or economically marginalised regions frequently bear the highest environmental burdens from ocean-related activities while receiving the least benefit. The concept of a social floor, analogous to ecosystem condition baselines in SEEA-EA, describes a minimum threshold of social conditions below which communities face structural harm. While the definition and measurement of a social floor for any particular context requires careful engagement with communities and local evidence, the concept is theoretically important because it frames Social Accounts as a tool for identifying and monitoring social risk, not only for describing social states.

¶7 **Table 3:** Types of social assets and conditions, example indicators and units.

Capital type	Description	Example indicators	Example units
Human capital	Knowledge, skills, health, and capabilities embodied in individuals and communities. Includes adaptive capacity, which shapes how communities respond to environmental and governance change.	Educational attainment; proportion of ocean-dependent households in poorest income quintile; household consumption of fish and seafood; life satisfaction score; proportion reporting fair or good physical and mental health; adaptive capacity index	Proportion (%); score; kg per capita per year

DRAFT

Capital type	Description	Example indicators	Example units
Relational capital	Networks, relationships, trust, and collective resources connecting coastal and ocean-dependent communities. Enables economic and social activities. Distinct from formal governance institutions, which are captured under institutional capital.	Level of cooperation between ocean-dependent sectors (within and across sectors); number of active community-based resource management groups; number of cross-community resource-sharing arrangements; proportion of ocean management groups with representative membership by gender and social group	Count; proportion (%); categorical scale
Institutional capital	Formal and informal rules, governance structures, and organisational systems regulating human interactions with the ocean. Includes access rights, co-management arrangements, and governance resilience.	Coverage of marine spatial planning or ecosystem-based management approaches (% of marine waters); compliance rates with fishing regulations; number of active co-management agreements; records of traditional and legally recognised tenure arrangements; marine law enforcement capacity (patrol hours and coverage)	Proportion (%); count; hours
Cultural capital	Cultural heritage, place-based identity, marine knowledge systems, and intergenerational practices that connect communities to the ocean. The body of Traditional Ecological Knowledge is a cultural capital stock; the act of sharing TEK is a social flow (see 3.3.2).	Number of active traditional marine governance practices; proportion of community members reporting strong cultural connection to the ocean; number of active cultural transmission programmes related to the sea; proportion of community members with knowledge of traditional ecological practices	Count; proportion (%); categorical scale
Social equity and conditions	Distributional conditions across all capital types: rights, access, voice, power, and well-being by social group and geography. A core condition, not confined to any single capital category. Includes access to basic coastal services, social protection, and safety.	Gini coefficient for ocean-sector income; proportion of fishing permits held by women; proportion of coastal management decisions with documented community participation; proportion of households with secure access to marine resources; access to basic coastal services (sanitation, clean water, connectivity)	Proportion (%); index; count

3.3.2 Social activities (flows)

¶1 Social activities are conceptualised as flows within this framework, representing actions and events that create, maintain, transform, or draw upon social assets and conditions during an accounting period. Social activities encompass human interactions with the ocean and with coastal life that occur outside the traditional SNA production boundary, which is largely limited to market transactions and certain types of production for own final use. Extending the accounting framework to include non-market social flows is a primary objective of Social Accounts. The classification of social activities into discrete categories reflects theoretically important domains of social life that conventional accounting does not capture. Unpaid household labour encompasses activities that extend the market economy, enable ocean-related economic activity, and sustain the social reproduction of coastal communities. Social transfer activities capture the informal reciprocal exchange that builds and sustains relational capital at the margins of formal social protection. Volunteering and community activities document the collective effort communities invest in managing shared resources and maintaining coastal environments. Cultural and recreational activities capture the lived

practices that reproduce cultural capital across generations. Governance and public engagement activities record the effort communities invest in participating in decisions that shape their lives and territories. A sixth category, knowledge exchange and capacity-building for ocean stewardship, captures the educational and knowledge-transmission activities that build and circulate human and cultural capital within and between communities. This addition responds to the recognition that knowledge transmission is a distinct and important social flow that earlier framings have not adequately represented. Each category corresponds to a social function that would otherwise be invisible in the accounts, and their inclusion together constitutes a claim that the social value generated outside the market is real, consequential, and measurable.

¶2 Social activities require multiple measurement units appropriate to the phenomenon being captured. Time measured in hours captures activities where duration reflects engagement intensity. Physical quantities measure material resources mobilised in social activities. Counts track frequency, participation, and occurrence. Proportions enable distributional analysis. Indices and scales assess subjective dimensions and multi-dimensional concepts. The primary unit in Table 4 is hours, which enables comparability across activities and connection to the broader time-use statistical tradition. However, the choice of hours as a primary unit reflects practical considerations of data availability rather than a claim that time is the primary dimension of social activity value. Alignment between Social Accounts and the SNA occurs at the stage of monetary valuation, not at the stage of physical recording: in physical accounting, any appropriate unit may be used. There are also important limitations to the hours unit that must be acknowledged. Hours-based measurement may be culturally inappropriate or analytically misleading for collective or ceremonial activities in Indigenous contexts, where participation is not fungible across individuals and where the meaning of an activity cannot be separated from its specific cultural form. Activities such as the provision of boats or fishing equipment are better captured in physical quantities. The informal economy, including subsistence fishing, gleaning, barter, and communal gear maintenance, must be captured within the flow categories, but care is required to avoid double-counting activities that also fall within the SNA production boundary. Table 4 includes multiple units and notes on data sources.

¶3 Social activity categories have flexible boundaries, and the framework is designed to accommodate this rather than require strict either/or classification. Sea rituals, for example, may simultaneously function as cultural activities and as governance mechanisms through which communities assert customary tenure and transmit ecological knowledge. Where an activity spans categories, the recommended approach is to assign it to the category most relevant to the primary social function being assessed and to note the overlap in accompanying metadata. The more consequential classification challenge concerns activities near the SNA production boundary. Social Accounts should record social flows only for the non-economic dimensions of an activity, such as the time spent in traditional processing methods, the cultural knowledge embedded in the activity, and the social relationships sustained through it, rather than the economic output produced, which is properly recorded in economic accounts. The imperative is to avoid double-counting: an activity recorded as an economic flow in economic accounts should not also be recorded as a social flow, except to the extent that it generates a distinct social dimension not captured in the economic account. Practical classification rules and worked examples are developed in companion compilation guidance. A minimum starter indicator set for Social Accounts in low-capacity and limited-data settings is also developed in that guidance, recognising that comprehensive Social Accounts require sustained investment in data systems and that development must be iterative.

¶4 **Table 4:** Types of social activities, example indicators, measurement units and typical data sources.

DRAFT

Category	Description	Example indicators	Measurement unit	Typical data sources
Unpaid household labour	Productive activities by household members for their own benefit that in principle could be delegated to a third party (third-party criterion). Includes activities that enable ocean-related economic activity and sustain community social reproduction.	Hours of community care for children of ocean workers; hours spent on food preparation from ocean resources; hours spent on household support while fishers are at sea; hours spent on maintenance and repair of fishing equipment; hours spent processing and preserving marine catch; hours of elder care in fishing communities; hours of labour undertaken by children at sea	Hours; physical quantities (kg)	Time-use surveys; household surveys; participatory research
Social transfer activities	Direct non-market provision of support between households, including informal care, equipment sharing, and mutual aid. Distinct from formal government social protection and from volunteering for organisations.	Hours spent providing fishing equipment to other families; hours of informal mutual aid during fishing seasons; hours of inter-household sharing of marine resources; hours of shelter or accommodation provision during displacement from coastal areas; number of households participating in mutual support networks during environmental disruption	Hours; count	Household surveys; community interviews; participatory research
Volunteering and community activities	Unpaid, non-compulsory activities performed for the benefit of others outside the household, including informal community assistance. Where activities are conducted through non-profit organisations, they fall within the SNA production boundary and should not be double-counted here.	Hours of individual beach cleanup; hours of personal marine conservation effort; hours of community-based coastal monitoring; hours of informal marine safety education; hours helping neighbours with fishing; hours of community stewardship of nearshore areas outside formal programmes	Hours; count	Time-use surveys; community records; participatory research

DRAFT

Category	Description	Example indicators	Measurement unit	Typical data sources
Cultural and recreational activities	Participation in ocean activities that contribute to individual and community well-being, cultural identity, and social cohesion. Includes cultural heritage, ceremonies, creative practices, sport, and recreation. Activities that cannot be undertaken on behalf of the individual, including ceremonial activities that simultaneously function as governance mechanisms, are included here; double-classification should be noted in metadata.	Hours of traditional ceremonies related to the sea; hours of cultural storytelling about marine environments; hours of spiritual practice connected to the ocean; hours of traditional boat building and maintenance; hours of ocean-based recreation (surfing, diving, traditional navigation, canoe practice); number of active ceremony cycles related to marine seasons	Hours; count	Cultural surveys; community records; participatory oral history; time-use surveys
Governance and public engagement	Activities related to participation in decision-making processes, access to justice, and the functioning of community-level governance for the ocean.	Hours of participation in community fisheries management; hours of involvement in marine protected area planning; hours of engagement in traditional governance systems; hours of customary marine tenure activities; hours of contribution to conflict resolution over marine resources; number of community meetings on ocean management participated in	Hours; count	Governance records; community surveys; participatory research
Knowledge exchange and capacity-building	Educational and knowledge-transmission activities that build and circulate human and cultural capital related to ocean stewardship. Includes formal and informal learning, intergenerational mentorship, and cross-community exchange.	Hours of ocean-related education and skills training; hours of intergenerational mentorship in traditional ecological knowledge; hours of community-to-community exchange on ocean stewardship; number of participants in ocean literacy programmes; number of traditional knowledge-sharing events held	Hours; count; number of participants	Education records; training records; community surveys; participatory research

DRAFT

3.3.3 Reading stocks and flows together: the framework in practice

¶1 The two entry points are designed to be read together, not in isolation. A stock indicator describes the condition of a social asset at a point in time; a flow indicator describes the activities that maintain, build, or deplete that condition over an accounting period. The stock-flow relationship is dynamic and bidirectional: social activities can accumulate social capital over time, as when community-based fisheries governance builds institutional resilience and relational trust or they can draw it down, as when prolonged environmental disruption depletes adaptive capacity and erodes the informal safety nets on which vulnerable communities depend. It is this dynamic relationship, made visible through repeated measurement across accounting periods, that allows Social Accounts to explain change over time rather than merely describe a snapshot. That figure therefore represents more than a structural diagram: it encodes a theoretical claim that understanding the social dimensions of ocean governance requires both a record of what exists: (i) the stocks of human, relational, institutional, and cultural capital that communities hold at any given moment and (ii) a record of what communities do, the flows of unpaid, informal, cultural, and civic activity that sustain, build, and sometimes deplete those stocks. Neither entry point is sufficient alone. Together, they constitute an integrated, interoperable framework capable of making visible precisely those dimensions of human-ocean relationships that conventional economic and environmental accounts have historically rendered absent.

Example: Relational capital

¶2 This example illustrates the stock-flow relationship in a different register. In many small-scale fishing communities, informal networks of reciprocal support (e.g. gear sharing, mutual aid during poor seasons, inter-household provision of food and care) constitute a critical form of social protection that operates entirely outside formal systems. These networks are a stock of relational capital. They represent accumulated trust, established relationships, and shared norms of reciprocity that have built up over time and that enable communities to absorb economic and environmental shocks.

¶3 Measuring this stock might involve counting the number of active community-based resource management groups, the number of cross-community resource-sharing arrangements, and assessing the level of cooperation between ocean-dependent households and sectors. Through disaggregation, these indicators could reveal asymmetries that aggregate figures conceal. For example, women may be central nodes in reciprocal support networks while remaining entirely absent from formal governance bodies, a distributional pattern that average participation rates would obscure. The corresponding flows are the social transfer activities and volunteering activities that sustain and draw upon these networks. For example, hours of informal mutual aid during fishing seasons, hours of inter-household sharing of marine resources, hours of shelter or accommodation provision during displacement from coastal areas. During a period of environmental disruption (e.g. a destructive cyclone, a prolonged harmful algal bloom, a sudden fisheries closure), these flows typically intensify as households draw heavily on relational capital to survive. If the disruption is severe or prolonged enough, the flows may eventually deplete the stock. The relationships of reciprocity erode under sustained pressure, trust breaks down, and the informal safety net that once absorbed shocks disappears.

¶4 Tracking both stock and flow indicators across accounting periods makes this dynamic visible in a way that a single cross-sectional survey cannot. A community that has experienced repeated environmental shocks may show declining relational capital stocks even as it reports high levels of mutual aid activity in the most recent period (i.e. a pattern that signals a system under stress rather than a resilient one). The policy implication is different in each case, and the account must be capable of distinguishing between them. The quantitative record is necessary but not sufficient. The number of households participating in mutual support networks during environmental disruption does not capture the quality of those relationships, the degree to which they are experienced as reliable and reciprocal, or the community's own sense of whether the social fabric is holding. Participatory assessments and community narratives, recorded systematically alongside the

DRAFT

quantitative indicators, provide the interpretive layer that gives the numbers their meaning and that ensures the account remains salient and recognisable to the communities it is meant to serve.

3.4 Legitimacy, knowledge systems and co-design

¶1 A theoretical account of Social Accounts cannot rest on quantitative data alone. This is not a concession to methodological pragmatism, it is an epistemological position about what knowledge is required to understand human-ocean relationships. Quantitative indicators, including hours, proportions, and counts, provide the structural backbone of Social Accounts and enable temporal comparison, spatial analysis, and cross-domain integration. However, many of the most important dimensions of human-ocean relationships, including cultural identity, spiritual connection, relational values, perceived well-being, and the experience of living well within a particular territory and seascape, cannot be reduced to numerical metrics without fundamental loss of meaning. This is not a limitation that can be solved by better measurement technology: it reflects the nature of the phenomena themselves. The epistemological argument for qualitative data within Social Accounts draws on the recognition that knowledge about social life takes multiple legitimate forms, of which numerical measurement is one. Qualitative approaches provide what quantitative data cannot: the interpretive context within which numbers become meaningful; the diversity of values, meanings, and lived experiences that aggregate statistics inevitably erase; the voices of individuals and communities who must be active participants in knowledge production rather than passive subjects of data collection; and the temporal and relational dynamics of social change that longitudinal indicators can track but cannot explain [17]. These four dimensions, context, meaning, voice, and dynamics, constitute the theoretical case for treating qualitative information not as supplementary to Social Accounts but as epistemically necessary for them.

¶2 Subjective well-being, meaning the perceived or lived experience of well-being rather than its objective indicators, is a legitimate and necessary dimension of Social Accounts that quantitative metrics alone cannot capture. Life satisfaction, sense of security, cultural belonging, and the experience of agency are dimensions of well-being that communities are best placed to assess and articulate. The SEEA-EA and the SNA 2025 both recognise the value of experiential and perceptual dimensions of the relationship between people and ecosystems. In the context of Social Accounts, subjective well-being assessments provide the interpretive frame that helps explain patterns in objective indicators, and they reveal dimensions of well-being that objective indicators systematically miss. The inclusion of qualitative and subjective data within Social Accounts requires more than documentation alongside quantitative data. It requires formal mechanisms through which qualitative findings are recorded, systematically reviewed, and used in decision-making. Qualitative evidence, including community narratives, focus group findings, oral histories, and participatory assessments, could be integrated into account tables through structured narrative columns, as has been demonstrated in experimental Indigenous ecosystem accounts in Australia [24]. In that context, the Yawuru concept of *mabu liyan*, a state of well-being derived from living well on Country, was recorded alongside quantitative data through a “benefits” column in ecosystem service tables [22]. This approach demonstrates that cultural specificity and quantitative rigour are not in tension: they are complementary dimensions of a more complete and legitimate account. Guidance on formats for qualitative recording within account structures is developed in subsequent compilation guidance.

¶3 The relationship between Social Accounts and Indigenous, Traditional, and Local Knowledge requires particular care, because the appropriate relationship is weaving rather than integration. Integration implies assimilation, a dominant system absorbs elements from another on the dominant system’s terms. Weaving implies genuine dialogue between distinct and autonomous knowledge systems: each contributes its own threads to a shared fabric without losing its own integrity or becoming subordinate to the other. This distinction matters because Indigenous knowledge systems embody distinct epistemologies, ontologies, and ethical frameworks that cannot be mapped onto the categories of formal accounting without distortion. The goal is Social Accounts that are

DRAFT

genuinely enriched by Indigenous and Traditional Knowledge, designed in ways that preserve the sovereignty of knowledge holders over their own knowledge. In practice, this means that the decision whether, how, and to what extent Indigenous or Traditional Knowledge enters formal Social Accounts rests with knowledge holders and with the governance systems through which communities exercise collective authority. Free, Prior, and Informed Consent (FPIC) is the minimum standard, but genuine co-design requires more: that communities have meaningful influence over the categories, methods, and governance structures of Social Accounts from the outset, not simply the right to refuse data collection after it has been designed without them. The groups most systematically underrepresented in existing accounts, including Indigenous Peoples, women, small-scale fishers, youth, and elders, should be explicitly named and included in co-design processes.
Social Accounts must also address the safety risks of publishing social data about vulnerable communities: the decision to make data publicly available should be a community-controlled governance decision, not an institutional one [24].

¶4 The legitimacy of Social Accounts depends not only on their technical coherence but on the processes through which they are designed, governed, and used. Community co-design is not a procedural courtesy: it is a condition of the framework's validity. Social Accounts designed without the active participation of the communities are meant to describe risk producing accounts that are technically complete but socially illegitimate, reflecting the priorities of institutions rather than the realities of lives. Participation in co-design is not performative consultation, where community input is sought after key decisions have already been made: it is a structural condition for the legitimacy and accuracy of the resulting accounts. This means that communities must have genuine decision-making authority over what is counted, how results are communicated, and how the accounts are used in policy and resource allocation. The principle of legitimacy through process applies directly to the Social Accounts theoretical framework itself. The revision of this guidance has been undertaken in response to the feedback of the Social Accounts Working Group, which includes practitioners and researchers from the communities and governance contexts where Social Accounts are being developed. Their feedback is the primary reference for what must change, and the act of responding to it substantively is itself a demonstration of the principle this section articulates.

DRAFT

¶5 The same principle extends to the governance of the framework itself. The categories, indicators, and units presented in this circular are not fixed instruments. They represent the best available conceptual guidance at the time of publication, developed through the Social Accounts Working Group process and grounded in pilot experience from Costa Rica, Belize, Mozambique, and the Maldives. As Social Accounts moves from conceptual foundation to operational practice, the framework requires mechanisms for structured review and revision that are as transparent and accountable as the framework itself claims to be.

¶6 The current capital categories and flow types will be subject to formal review following the completion of the first round of pilot programmes. Reviews will be coordinated through the GOAP Secretariat, with substantive input from the Social Accounts Working Group, national statistical partners, and the communities in whose contexts the accounts are being applied. Decisions about category changes or additions require documented justification, transparent consultation, and explicit consideration of how revisions affect comparability with data compiled under earlier versions of the framework. No category should be added, removed, or redefined without that process. The standard indicator sets developed in companion compilation guidance are subject to the same governance logic, with the additional requirement that communities who have contributed data under existing indicator definitions are informed of proposed changes and given meaningful opportunity to respond before those changes are adopted.

3.5 Decision Use-Cases for Social Accounts

¶1 Social accounts for oceans serve three primary decision contexts that require integrated documentation of human-ocean relationships. Understanding these use-cases helps clarify why social accounts are compiled and what analytical requirements they must satisfy.

3.5.1 Equity and distributional assessments

¶1 Ocean resources generate substantial economic value, but benefits and burdens are not evenly distributed across population groups. Social accounts enable systematic assessment of who gains and who bears costs from ocean use patterns, supporting decisions about resource allocation, access rights, and benefit-sharing mechanisms.

¶2 Equity assessments inform decisions including:

- ¶3 Allocation of fishing quotas between industrial and small-scale sectors
- ¶4 Distribution of marine protected area costs and benefits across coastal communities
- ¶5 Design of compensation mechanisms for communities displaced by coastal development
- ¶6 Targeting of ocean-related social protection programs

¶7 The distributional data compiled in social accounts relate to the governance rules documented in **TG-3.7 Governance Accounts**. Governance accounts record the institutional arrangements that determine access to ocean resources; social accounts document the distributional outcomes that result from those governance decisions. Section 3.3.1 of TG-3.7 specifically notes that "the governance rules documented here shape the distributional outcomes recorded in social accounts." Compilers should coordinate social and governance accounting to ensure that institutional rules can be linked to observed distributional patterns.

3.5.2 Community dependency and vulnerability analysis

¶1 Coastal and ocean-dependent communities face particular vulnerabilities to environmental change, economic shocks, and governance failures. Social accounts document dependency patterns and adaptive capacity, supporting decisions about resilience-building investments, livelihood diversification programs, and climate adaptation planning.

¶2 Dependency analysis informs decisions including:

- ¶3 Prioritization of coastal communities for climate adaptation finance
- ¶4 Design of fisheries transition programs for workers displaced by stock collapse
- ¶5 Siting decisions for marine spatial planning that affect community access
- ¶6 Targeting of social services and infrastructure investments in coastal areas

¶7 These vulnerability assessments draw on ecosystem condition data from **TG-3.1 Asset Accounts** Sections 3.5.1–3.5.2, which document the biophysical changes that threaten community wellbeing. The social accounts compiled under this Circular provide the socioeconomic profile data needed to assess which communities are most exposed and least able to cope with environmental degradation documented through condition and ecosystem accounts.

3.5.3 Just transition planning

¶1 As economies transition toward sustainable ocean use, workers and communities dependent on unsustainable practices face potential displacement. Social accounts support just transition planning by documenting the characteristics of affected workers, the adequacy of social protection coverage, and the availability of alternative livelihood options.

¶2 Just transition planning informs decisions including:

- ¶3 Design of retraining programs for fishers displaced by quota reductions
- ¶4 Social protection extensions for informal workers in ocean sectors
- ¶5 Community development programs for areas affected by marine conservation measures
- ¶6 Gender-responsive transition policies recognizing differential impacts on women and men

DRAFT

¶7 The employment and working conditions data compiled in social accounts (Sections 3.6.2 and 3.6.3 below) provide the empirical basis for assessing transition needs. These data connect to the economic structure documented in **TG-3.3 Economic Activity Relevant to the Ocean**, which provides the industry-level context for understanding which sectors are most affected by sustainability transitions and what economic alternatives may be available.

3.6 Wellbeing Indicators

¶1 Wellbeing encompasses the multidimensional aspects of human welfare that extend beyond income and consumption to include health, security, social connections, and subjective life satisfaction. The ocean contributes to human wellbeing through multiple pathways, both material and non-material.

¶2 The wellbeing framework presented here aligns with the 2025 SNA Chapters 34 (Measuring Well-being) and 35 (Measuring the Sustainability of Well-being), which provide the conceptual foundation for extending national accounts to encompass broader dimensions of human welfare. As methodological guidance in this area continues to develop at the international level, compilers should monitor updates to these chapters and adjust their compilations accordingly.

3.6.1 Framework for ocean-related wellbeing

¶1 The 2025 SNA establishes that "a unique feature of the 2025 SNA is the broadening of the national accounts framework to better account for elements affecting wellbeing and sustainability to inform various policy goals"[2]. Chapter 34 (Measuring Well-being) and Chapter 35 (Measuring the Sustainability of Well-being) provide the conceptual foundation.

¶2 For ocean accounting, wellbeing indicators can be organized across several domains:

¶3 **Material wellbeing:** Income, consumption, and wealth derived from ocean resources, including:

> *Definitional box: Ocean-dependent household* *For the purposes of Social Accounts, an ocean-dependent household is defined as one that derives more than 50% of total household income from ocean industries or subsistence fishing (including imputed value of subsistence harvests). This threshold is an analytical convention — not a statutory or regulatory classification — adopted to enable consistent identification of ocean-dependent populations across data sources. It is consistent with livelihood dependency definitions used in FAO Small-Scale Fisheries Guidelines. Compilers are encouraged to test the sensitivity of results using thresholds of 30% and 70% to assess the robustness of dependency classifications to the choice of cut-off. The threshold and any sensitivity tests applied must be documented in the compilation metadata. Cross-reference: the 50% threshold is applied in the worked example in Section 4.5.2.*

- ¶4 Household income from fishing, aquaculture, and other ocean industries
- ¶5 Value of subsistence harvests from marine resources
- ¶6 Household consumption of seafood and marine products
- ¶7 Wealth held in fishing vessels, aquaculture assets, and coastal property

¶8 Where subsistence harvests are a significant livelihood component, physical quantity (kg per capita per year of marine catch) is the primary indicator. Where monetary valuation is required, apply local market price imputation using prices for equivalent species from the nearest market. For detailed guidance on physical quantity measurement of subsistence production, see SEEA AFF Chapter 5; for valuation approaches adaptable to subsistence contexts, see **TG-2.4 Ecosystem Goods and Services**.

¶9 These material dimensions connect directly to economic accounts. For guidance on measuring economic contributions of ocean industries, see **TG-3.3 Economic Activity Relevant to**

the Ocean.

¶10 **Employment and livelihoods:** Work-related dimensions of wellbeing associated with ocean sectors, including:

- ¶11 Employment in ocean industries (fishing, aquaculture, tourism, shipping, offshore energy)
- ¶12 Job quality indicators (wages, working conditions, job security)
- ¶13 Livelihood diversification and dependence on marine resources
- ¶14 Skills and training opportunities in ocean sectors

¶15 The classification of ocean industries follows the framework established in **TG-3.3 Economic Activity Relevant to the Ocean**, which provides standardized definitions aligned with ISIC and CPC.

¶16 **Health outcomes:** Physical and mental health effects related to ocean environments, including:

- ¶17 Nutritional contributions from seafood consumption
- ¶18 Health risks from ocean-related occupations
- ¶19 Mental health and stress reduction from coastal access
- ¶20 Water quality impacts on coastal community health

¶21 **Food security:** Access to adequate and nutritious food derived from marine sources, including:

- ¶22 Household-level fish consumption and dietary diversity
- ¶23 Contribution of marine protein to national food supply
- ¶24 Vulnerability of food systems to marine resource depletion
- ¶25 Access to subsistence fishing and gleaning for food-insecure populations

¶26 Food security is closely linked to both material wellbeing and health outcomes, and serves as a key channel through which ocean ecosystem condition affects human welfare. SDG 2 (Zero Hunger) and its targets on food security and nutrition are directly relevant where coastal and island populations depend on marine protein as a primary food source.

¶27 **Cultural and spiritual wellbeing:** Non-material dimensions of human-ocean relationships, including:

- ¶28 Access to culturally significant marine sites
- ¶29 Maintenance of traditional practices and knowledge
- ¶30 Sense of place and identity connected to coastal environments
- ¶31 Intergenerational transmission of marine-related culture

¶32 For guidance on documenting traditional marine knowledge and customary practices, see **TG-3.6 Traditional Knowledge Accounts**.

¶33 **Recreation and leisure:** Benefits from using ocean environments for non-work activities, including:

- ¶34 Participation in marine recreation (swimming, diving, fishing)
- ¶35 Access to coastal amenities
- ¶36 Tourism experiences in marine environments

¶37 The SEEA Ecosystem Accounting framework identifies cultural services as "experiential and intangible services related to the perceived or actual qualities of ecosystems whose existence and functioning contribute to a range of cultural benefits"[3]. These include recreation-related services, visual amenity services, education and research services, and spiritual, artistic and symbolic services. For ocean accounting, these cultural ecosystem services represent important contributions to wellbeing. See **TG-2.4 Ecosystem Goods and Services** for guidance on measuring ecosystem services in monetary and physical terms.

DRAFT

¶38 **Environmental quality:** The condition of the local marine and coastal environment as experienced by communities, including:

- ¶39 Water quality for recreation, fishing, and domestic use
- ¶40 Air quality in coastal and port areas
- ¶41 Noise and visual amenity from marine activities
- ¶42 Exposure to marine pollution and litter

¶43 Environmental quality operates as a mediating factor between ecosystem condition (documented in **TG-2.1 Biophysical Indicators**) and perceived wellbeing, and may be assessed through both objective measurements and resident perception surveys.

3.6.2 Measuring ocean sector employment

¶1 Employment in ocean sectors is a primary pathway through which oceans contribute to material wellbeing. The Statistical Framework for Measuring the Sustainability of Tourism (SF-MST) provides relevant measurement approaches that can be adapted for ocean accounting.

¶2 The SF-MST defines employment as "all those of working age who, during a short reference period, were engaged in any activity to produce goods or provide services for pay or profit"[4]. For ocean accounts, employment should be compiled for industries directly dependent on marine resources or operating in marine spaces. To ensure consistency with economic accounts, employment measurement in social accounts should use the same industry classifications as those established in **TG-3.3 Economic Activity Relevant to the Ocean**, including the ISIC-based ocean economy concordance provided in that Circular.

¶3 Key ocean sectors for employment measurement include:

¶4 **Fisheries and aquaculture:** SDG Target 2.3 calls for doubling "the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers"[5]. Employment accounts should distinguish between:

- ¶5 Commercial fishing (industrial and semi-industrial)
- ¶6 Small-scale and artisanal fishing
- ¶7 Aquaculture (marine and brackish water)
- ¶8 Fish processing and marketing

¶9 The SEEA for Agriculture, Forestry and Fisheries (SEEA AFF) provides an integrated framework for describing how "biophysical and management information relevant to agriculture, forestry and fisheries production can be integrated into the statistical framework"[6]. For comprehensive guidance on fisheries measurement, see **TG-1.5 Fisheries Management**.

¶10 **Marine tourism:** SDG Target 8.9 calls for implementing "policies to promote sustainable tourism that creates jobs"[7]. Employment in marine tourism includes:

- ¶11 Accommodation services in coastal areas
- ¶12 Tour operators and guides for marine activities
- ¶13 Water-based transport for tourism purposes
- ¶14 Recreational fishing services

¶15 **Maritime transport and ports:** Employment in shipping, port operations, and related logistics

¶16 **Offshore energy:** Employment in oil and gas extraction, offshore wind, and other marine energy

¶17 **Other ocean industries:** Shipbuilding, marine biotechnology, coastal construction

¶18 The classification of ocean industries follows the framework established in **TG-3.3 Economic Activity Relevant to the Ocean**...

DRAFT

¶19 Table 1a provides a summary concordance between key ocean industry categories and 2-digit ISIC Rev. 4 codes. For full definitions and sub-category codes, see TG-3.3.

¶20 *Table 1a: Summary concordance — ocean industry categories and ISIC Rev. 4*

Ocean industry category	ISIC Rev. 4 division(s)	Notes
Marine capture fisheries	03 (Fishing and aquaculture)	Partially ocean: exclude freshwater fishing using vessel registry or catch data
Aquaculture (marine/brackish)	03	Partially ocean: exclude freshwater operations
Fish processing and marketing	10 (Food manufacturing)	Partially ocean: exclude freshwater species where distinguishable
Water transport (maritime)	50 (Water transport)	Partially ocean: ISIC 50 includes inland waterway transport — attribute share to ocean using vessel registry or port throughput statistics
Coastal and marine tourism	55 (Accommodation), 56 (Food/beverage), 79 (Travel agencies), 93 (Sport)	Partially ocean: apply coastal tourism satellite account methodology or geographic filter
Offshore energy extraction	06 (Oil and gas extraction)	Partially ocean: offshore operations only
Shipbuilding and repair	30.1 (Building of ships and boats)	Fully ocean-related
Port operations and services	52 (Warehousing and transport support)	Partially ocean: exclude inland terminals

¶21 For ISIC groups that are only partially attributable to ocean industries (e.g., ISIC 50 Water transport), compilers should apply a proportional allocation using vessel registry data, port throughput statistics, or national ocean economy satellite account ratios where available. The allocation method and ratio applied must be documented.

¶22 The SF-MST recommends that employment data be compiled with characteristics relevant to social sustainability, including [8]:

- ¶23 Sex (male/female)
- ¶24 Age groups
- ¶25 Employment status (employee, self-employed, contributing family worker)
- ¶26 Full-time/part-time status
- ¶27 Contract type (permanent, temporary, seasonal)
- ¶28 Formal/informal employment status
- ¶29 Geographic location

¶30 SDG Target 14.7 commits countries to increasing the economic benefits that small island developing States and least developed countries derive from the sustainable use of marine resources [9]; its indicator 14.7.1 measures "Sustainable fisheries as a proportion of GDP in small island developing States, least developed countries and all countries" [10]. Employment accounts provide complementary information on the livelihood dimensions of sustainable fisheries.

3.6.3 Decent work dimensions

¶1 The ILO Decent Work Measurement Framework encompasses ten substantive elements: employment opportunities; adequate earnings and productive work; decent working time; combining work, family and personal life; work that should be abolished; stability and security of work; equal opportunity and treatment in employment; safe work environment; social security; and social dialogue [11].

¶2 For ocean sectors, several decent work challenges deserve particular attention:

¶3 **Occupational safety:** Fishing is among the most hazardous occupations globally, with elevated rates of fatal and non-fatal injuries. SDG indicator 8.8.1 measures "Frequency rates of fatal and non-

DRAFT

fatal occupational injuries, by sex and migrant status" [12].

¶4 **Informal employment:** Many ocean-sector workers, particularly in small-scale fisheries, operate in the informal economy. SDG indicator 8.3.1 measures the "Proportion of informal employment in non-agriculture employment" [13]. Ocean accounts should document the proportion of informal employment in ocean industries. The 2025 SNA Chapter 39 on the informal economy provides updated guidance aligned with recent ICLS resolutions.

¶5 **Seasonal employment:** Tourism and fishing often involve seasonal work patterns that affect income stability. The SF-MST notes that "employment in tourism industries is known for the fact that it often consists of a small core of permanent staff complemented with staff with a temporary contract and on-call workers" [14].

¶6 **Migrant workers:** Ocean industries, particularly fishing and maritime transport, often rely significantly on migrant labour. SDG Target 8.8 calls for protecting "labour rights and promote safe and secure working environments for all workers, including migrant workers" [15].

¶7 Table 1 summarizes the recommended employment indicators for ocean social accounts, with suggested disaggregations to support distributional analysis.

¶8 *Table 1: Recommended employment indicators for ocean social accounts*

Indicator	Recommended Disaggregation	Data Source
Employment rate in ocean industries	Sex, age group, coastal/inland	Labour force surveys
Average wages in ocean industries	Sex, industry, compared to national average	Establishment surveys, administrative records
Share of part-time employment	Sex, industry, seasonal/non-seasonal	Labour force surveys
Proportion of informal employment	Sex, industry, urban/rural	Labour force surveys, ICLS definitions
Work-related injury and illness rates	Sex, industry, migrant status	Administrative records, occupational health data
Share of self-employed workers	Sex, industry, own-account/employer	Labour force surveys
Seasonal employment share	Industry, contract type	Labour force surveys, tourism statistics

DRAFT

¶9 These indicators align with both the ILO Decent Work Measurement Framework and the SF-MST recommendations on employment data characteristics [16].

3.6.4 Subjective wellbeing measures

¶1 Beyond objective indicators, subjective wellbeing measures capture how people evaluate and experience their lives. The OECD Guidelines on Measuring Subjective Well-being provide methodological standards for measuring life satisfaction, affect, and eudaemonic wellbeing [17].

¶2 For ocean accounting, subjective measures can assess:

¶3 **Life satisfaction:** Overall life satisfaction of coastal and ocean-dependent populations compared to national averages

¶4 **Domain satisfaction:** Satisfaction with specific life domains affected by ocean conditions (e.g., work satisfaction among fishers, satisfaction with local environment among coastal residents)

¶5 **Perceptions of wellbeing impacts:** Community perceptions of whether ocean-related activities (tourism, fishing, aquaculture) positively or negatively affect local wellbeing

¶6 The SF-MST recommends that measurement of tourism impacts on host communities include "perceptions on the negative and positive contribution of tourism to overall wellbeing" [18]. Similar approaches apply to other ocean-related activities affecting coastal community wellbeing.

3.7 Equity and Distribution

¶1 Equity concerns how the benefits and burdens of ocean use are distributed across population groups. Ocean accounting should document distributional patterns to support policy analysis for SDG 10 (Reduce inequality within and among countries). The governance frameworks that shape access to ocean resources and determine the distribution of benefits are documented in **TG-3.7 Governance Accounts**; social accounts record the distributional outcomes that result from those governance arrangements. Compilers should ensure that social accounts and governance accounts are compiled in a coordinated manner, so that the institutional rules documented in TG-3.7 can be linked to the distributional patterns recorded here.

3.7.1 Distributional dimensions

¶1 The 2025 SNA recommends standard breakdowns for household sector accounts by income decile and wealth quintile, as well as alternative breakdowns by main source of income, household type, housing status, and age of reference person[19]. Ocean accounts should adopt these breakdowns where relevant data exist, with particular attention to:

¶2 **Geographic distribution:** Benefits and burdens distributed across coastal and inland regions, urban and rural areas, and different coastal zones. Coastal communities may bear disproportionate environmental burdens (pollution, erosion, storm damage) while access to marine resources may benefit geographically concentrated populations.

¶3 **Income distribution:** How ocean-derived income is distributed across income groups. Small-scale fisheries often provide crucial livelihoods for lower-income households, while benefits from tourism and offshore industries may accrue disproportionately to higher-income groups or external investors.

¶4 **Gender distribution:** Women play significant but often under-recognized roles in ocean economies, particularly in fish processing, aquaculture, and gleaning. The UNWTO Global Report on Women in Tourism identifies "an urgent need for regular collection and reporting on employment data disaggregated by sex in tourism, also including formal and informal tourism employment, pay gaps"[20].

¶5 **Intergenerational distribution:** How current patterns of ocean use affect opportunities for future generations, connecting to sustainability accounting approaches in 2025 SNA Chapter 35 (Measuring the Sustainability of Well-being).

¶6 **Distribution among Indigenous Peoples and Local Communities:** Ocean resources often have particular significance for Indigenous Peoples and coastal communities with traditional marine tenure systems. The TNFD notes that "Indigenous Peoples and Local Communities manage or have tenure over at least 38% of remaining intact forest areas and 36% of areas that are key to biodiversity"[21], with analogous relationships existing for traditional marine areas. See **TG-3.6 Traditional Knowledge Accounts** for guidance on documenting these relationships.

¶7 *Table 2: Ocean social indicator framework*

Wellbeing Domain	Indicator	Data Source	Disaggregation
Material living	Household income from ocean	Household surveys	Coastal/inland, gender
Employment	Ocean jobs, quality	Labour surveys	Sector, formal/informal
Health	Fish consumption, protein	Dietary surveys	Income group, region
Cultural identity	Traditional practices	Qualitative surveys	Community, age
Recreation access	Marine recreation participation	Time-use surveys	Income, proximity

3.7.2 Access to ocean resources

DRAFT

¶1 UNCLOS establishes a framework for resource access in which coastal States have sovereign rights over resources in their EEZ while maintaining freedoms of access to the high seas. Within national waters, domestic governance frameworks determine how access rights are allocated. For documentation of these governance frameworks, see **TG-3.7 Governance Accounts**.

¶2 SDG Target 14.b calls for providing "access for small-scale artisanal fishers to marine resources and markets" [22]. Indicator 14.b.1 measures "Progress by countries in the degree of application of a legal/regulatory/policy/institutional framework which recognizes and protects access rights for small-scale fisheries" [23].

¶3 Access equity concerns include:

- ¶4 Allocation of fishing quotas and licenses across commercial and small-scale sectors
- ¶5 Rights of traditional fishers in the context of expanding commercial and tourism uses
- ¶6 Access to coastal land and beaches for fishing communities
- ¶7 Distribution of marine protected area benefits and restrictions

¶8 Marine spatial planning processes allocate marine space among competing uses, with significant equity implications. See **TG-1.2 Marine Spatial Planning** for related guidance on how spatial allocation decisions can be documented.

¶9 Social accounts should document the types and distribution of access rights using administrative data sources where available. Fishing licence registries, quota allocation records, marine protected area permits, and coastal land tenure records all provide information on who holds access rights and under what conditions. For guidance on accessing and using such administrative data sources, see **TG-4.3 Administrative Data**. Compilers should record the number of licences or permits by type, the demographic characteristics of holders (where available), and changes in allocation over time.

3.7.3 Benefit sharing

¶1 UNCLOS establishes principles of equitable benefit sharing, particularly for resources in the Area (seabed beyond national jurisdiction) and for continental shelf resources beyond 200 nautical miles. Article 140 states that "activities in the Area shall…be carried out for the benefit of mankind as a whole…taking into particular consideration the interests and needs of developing States" [24]. The Kunming-Montreal Global Biodiversity Framework and the BBNJ Agreement extend benefit sharing provisions to marine genetic resources.

¶2 Social accounts should document benefit-sharing information at the level of feasibility, using the following stratification:

¶3 **(a) Required:** Revenue from fishing access fees and marine protected area user charges, sourced from government fiscal accounts or ministry of fisheries administrative records. Compile total revenue received and, where available, its distribution by destination (e.g., national consolidated fund, coastal community development fund, protected area management agency).

¶4 **(b) Recommended:** Distribution of conservation finance by stakeholder category (government agencies, local communities, NGOs, private sector). Where conservation finance data are available from TG-1.7, compile flows by recipient type.

¶5 **(c) Aspirational / long-term:** Sharing of benefits from marine genetic resources, including royalties under national access and benefit-sharing legislation implementing the Nagoya Protocol and the BBNJ Agreement. This category is flagged as out of scope for most current compilations: most NSOs do not have access to commercial genetic resource contracts, and no internationally endorsed methodology for attributing value exists. Compilers should note the gap and monitor evolving guidance from the IPBES and CBD processes.

¶6 For guidance on documenting financial flows related to ocean conservation and management, see **TG-1.7 Multilateral Finance** and **TG-1.8 Project Finance**. For genetic resource benefit flows,

DRAFT

note that this is the subject of ongoing IPBES/CBD technical work.

¶7 SDG Target 15.6 (applicable also to marine contexts) calls for promoting "fair and equitable sharing of the benefits arising from the utilization of genetic resources" [25].

3.8 Vulnerability and Resilience

¶1 Coastal and ocean-dependent communities face particular vulnerabilities to environmental change, economic shocks, and governance failures. Social accounts should document vulnerability indicators and adaptive capacity to inform resilience-building policies.

3.8.1 Understanding vulnerability

¶1 The IPCC defines vulnerability as "the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt" [26].

¶2 Ocean-related vulnerabilities include:

¶3 **Climate vulnerability:** Exposure to sea level rise, coastal erosion, ocean warming, acidification, and changing storm patterns. SDG Target 1.5 calls for building "the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events" [27]. SDG Target 14.2 calls for managing marine ecosystems "including by strengthening their resilience" [28].

¶4 For guidance on documenting ecosystem condition changes that affect community vulnerability, see **TG-2.1 Biophysical Indicators** and **TG-3.1 Asset Accounts** Section 3.5.2.

¶5 **Economic vulnerability:** Dependence on volatile marine commodity markets, seasonal income fluctuations, and exposure to external economic shocks. The SF-MST notes that "the measurement of water use by tourism industries relative to water availability will provide insights into the dependence of tourism activity on a given water supply and the associated potential vulnerability of tourism activity to the effects of drought" [29]. Similar vulnerability assessments apply to fisheries dependent on stocks affected by environmental variability.

¶6 **Social vulnerability:** Factors that affect capacity to cope with and recover from shocks, including poverty, limited education, social marginalization, and weak social protection coverage.

¶7 **Ecological vulnerability:** Dependence on ecosystem services from marine ecosystems that may be degraded or at risk. The TNFD notes that "the prosperity and resilience of our societies and economies depend on the health and resilience of nature and its biodiversity" [30]. For guidance on documenting ecosystem condition and degradation, see **TG-3.1 Asset Accounts**.

¶8 Vulnerability assessment for coastal communities remains an active area of methodological development. While composite vulnerability indices have been proposed in the academic literature, no single standardized index has yet achieved international statistical endorsement. Compilers are encouraged to compile the component indicators listed in section 3.8.2 and to document the specific methods and weights used in any composite measures they produce, to support transparency and comparability as international guidance evolves.

3.8.2 Vulnerability indicators

¶1 Social accounts should compile indicators across multiple vulnerability dimensions:

¶2 **Exposure indicators:**

- ¶3 Proportion of population in coastal flood zones
- ¶4 Share of economic activity dependent on marine resources
- ¶5 Proportion of households dependent on fish for protein
- ¶6 Share of employment in climate-sensitive ocean sectors

DRAFT

¶7 **Sensitivity indicators:**

- ¶8 Poverty rates in coastal communities
- ¶9 Proportion of informal workers in ocean sectors
- ¶10 Age structure of fishing workforce
- ¶11 Nutritional dependence on marine protein

¶12 **Adaptive capacity indicators:**

- ¶13 Social protection coverage for ocean-sector workers
- ¶14 Access to financial services and insurance
- ¶15 Educational attainment in coastal communities
- ¶16 Livelihood diversification options
- ¶17 Strength of social networks and community organizations

¶18 SDG indicator 1.3.1 measures the "Proportion of population covered by social protection floors/systems"[31]. For ocean accounts, this indicator should be compiled specifically for coastal and ocean-dependent populations to assess protective capacity against shocks.

3.8.3 Resilience assessment

¶1 Resilience refers to "the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation"[32].

¶2 The TNFD recommends that organizations "describe the resilience of the organisation's strategy to nature-related risks and opportunities, taking into consideration different scenarios"[33]. For community-level resilience in ocean contexts, analogous assessments should consider:

¶3 **Ecological resilience:** The capacity of marine ecosystems to maintain functions and services under changing conditions. This connects to ecosystem condition accounts documented in **TG-3.1 Asset Accounts** Section 3.5.2.

¶4 **Economic resilience:** The capacity of ocean-dependent economies to maintain income and employment under changing conditions, including through diversification and adaptation.

¶5 **Social resilience:** The capacity of communities to maintain social cohesion, cultural practices, and collective action capacity under changing conditions.

¶6 **Governance resilience:** The capacity of institutions to adapt management approaches in response to changing conditions. See **TG-3.7 Governance Accounts** for documentation of adaptive governance capacity.

3.9 Qualitative Approaches

¶1 Many dimensions of ocean-society relationships are not readily captured through quantitative indicators. Qualitative approaches complement statistical measurement by documenting narratives, perceptions, and complex social dynamics.

3.9.1 Value of qualitative data

¶1 The SEEA Ecosystem Accounting framework acknowledges that some ecosystem contributions to wellbeing extend beyond what can be captured in supply and use tables. Cultural services in particular involve "experiential and intangible" dimensions[34] that require interpretive approaches.

¶2 Qualitative data provides:

- ¶3 **Context:** Understanding the local circumstances that shape quantitative indicators
- ¶4 **Meaning:** Interpreting what statistical patterns signify for affected communities
- ¶5 **Voice:** Ensuring that community perspectives inform accounting and policy

DRAFT

- ¶6 **Dynamics:** Capturing processes of change that snapshot indicators may miss

3.9.2 Participatory approaches

¶1 Engagement with Indigenous Peoples, Local Communities, and affected stakeholders is essential for social accounts that accurately represent human-ocean relationships.

¶2 The TNFD provides guidance on engagement processes that should [35]:

- ¶3 Identify relevant stakeholders including Indigenous Peoples and Local Communities
- ¶4 Respect the rights of Indigenous Peoples as reflected in the UN Declaration on the Rights of Indigenous Peoples
- ¶5 Document concerns and priorities expressed through engagement
- ¶6 Ensure equitable access and benefit sharing, particularly for Indigenous Peoples and Local Communities
- ¶7 Report on how engagement results are incorporated into decision-making

¶8 For ocean accounting, participatory processes can inform:

- ¶9 Identification of culturally significant marine areas and species
- ¶10 Assessment of wellbeing impacts from ocean management decisions
- ¶11 Documentation of traditional knowledge relevant to marine resource management
- ¶12 Evaluation of equity in resource access and benefit distribution

¶13 **TG-3.6 Traditional Knowledge Accounts** provides detailed guidance on documenting traditional ecological knowledge and customary governance systems through culturally appropriate methods. Compilers preparing social accounts should coordinate closely with the TG-3.6 guidance to ensure that participatory methods are consistent and that qualitative findings from both accounts can be cross-referenced. In particular, the protocols for free, prior and informed consent (FPIC) and community validation described in TG-3.6 apply equally to social accounts that involve engagement with Indigenous Peoples and Local Communities.

3.9.3 Community wellbeing assessment

¶1 The SF-MST framework for measuring tourism impacts on host communities provides an adaptable model for assessing ocean-related impacts on community wellbeing. Key elements include [36]:

¶2 **Resident perceptions:** Surveys and consultations that document how community members perceive the impacts of ocean-related activities (fishing, tourism, aquaculture, offshore development) on their wellbeing, cultural identity, and living environment.

¶3 **Social context impacts:** Assessment of effects on "cultural identity, living environment and wellbeing…including, for example, impacts on the quality of life, employment and income, cultural heritage, prevailing beliefs, and the access to services such as health care, education, transport and infrastructure, and housing" [37].

¶4 **Comparison across locations:** Analysis comparing conditions in communities with different levels of ocean-related activity to identify attributable impacts.

¶5 **Time-series monitoring:** Repeated assessment to track changes in community wellbeing over time in relation to changing ocean conditions and management approaches.

3.9.4 Narrative accounts

¶1 Beyond structured surveys and assessments, social accounts can incorporate narrative documentation:

¶2 **Case studies:** Detailed documentation of specific communities, sectors, or policy interventions that illustrate how ocean-society relationships function in particular contexts

DRAFT

¶3 **Oral histories:** Documentation of how ocean-society relationships have changed over time, particularly valuable for capturing traditional knowledge and intergenerational perspectives

¶4 **Stakeholder testimonies:** First-person accounts from fishers, coastal residents, tourism workers, and others directly affected by ocean conditions and management decisions

¶5 These narrative elements provide qualitative richness that complements quantitative indicators and supports communication of accounting results to diverse audiences.

¶6 **Archival and citation standards for qualitative materials:** Oral histories, stakeholder testimonies, and community consultation records collected for Social Accounts are subject to the following minimum archival standard:

- ¶7 **Storage:** Raw recordings and transcripts must not be published. They are to be retained under secure storage by the compiling agency for a minimum of seven years from the date of the account to which they relate, after which they may be disposed of in accordance with national data retention policy.
- ¶8 **Metadata:** Each qualitative source must be described by anonymised metadata recording: community type (e.g., fishing village, urban coastal suburb), geographic zone (coastal sub-region or district), date of collection (month and year), and thematic coverage (wellbeing domain as per Section 3.6.1). Personally identifying information must not appear in the metadata record.
- ¶9 **Citation format:** Published Social Accounts should cite qualitative sources using the format: "Community consultation, [community type], [coastal sub-region], [month/year]." Individual names must not be used unless the person has given explicit, documented consent to named citation.
- ¶10 **Consent:** Community consent to archive, cite, and use materials in published accounts must be obtained before collection begins, following the FPIC protocols described in **TG-3.6 Traditional Knowledge Accounts**. The consent scope (what materials may be archived, under what conditions) must be documented alongside the metadata record.

DRAFT

4. Compilation Procedure

4.1 Step-by-step compilation process

¶1 Compiling social accounts for ocean contexts follows a structured sequence that ensures consistent coverage and integration with other account components. The procedure below outlines the typical workflow; compilers should adapt it to national circumstances and data availability.

4.1.1 Define accounting boundaries

¶1 **Step 1.1: Delineate ocean-dependent populations** Identify the geographic areas and population groups whose wellbeing is materially affected by ocean conditions or management decisions. Use the following tiered delineation protocol:

¶2 **(a) Preferred:** Use administrative units (districts, municipalities, census enumeration areas) that overlap with the coastal zone as defined in national spatial data or the national coastal management framework. This ensures alignment with existing statistical geography and enables integration with census and survey microdata.

¶3 **(b) Fallback:** Where no official coastal zone definition exists, use the lowest-level administrative unit whose centroid or any part intersects within 50 km of the shoreline. Document the administrative unit level and the intersection rule applied.

¶4 Workers employed in ocean industries but residing outside the delineated coastal buffer should be assigned to the coastal buffer zone for employment compilation purposes; this assignment should be documented in the compilation metadata. The spatial delineation should align with the ecosystem accounting areas defined in **TG-3.1 Asset Accounts** and the spatial units used in **TG-1.2**

Marine Spatial Planning to facilitate cross-account linkages. See also **TG-4.2 Survey Methods** for stratification implications when designing survey samples for coastal subpopulations.

¶5 **Step 1.2: Identify ocean industries** Adopt the ocean industry classification from **TG-3.3 Economic Activity** to ensure consistency between social and economic accounts. Document the ISIC codes that correspond to each ocean industry category used in the account.

4.1.2 Compile employment accounts

¶1 **Step 2.1: Extract ocean employment from labour force surveys** Use labour force survey microdata to tabulate employment in ocean industries as classified in Step 1.2. Disaggregate by:

- ¶2 Sex (male/female)
- ¶3 Age group (15-24, 25-44, 45-64, 65+)
- ¶4 Employment status (employee, self-employed, contributing family worker)
- ¶5 Full-time/part-time status
- ¶6 Formal/informal status: apply the 17th International Conference of Labour Statisticians (ICLS) concept of informal employment (employment in informal jobs, regardless of the type of enterprise). Where labour force survey ISIC coding is too aggregated to isolate ocean industries, assign informal status using the following proxy hierarchy: (i) establishment size below five workers; (ii) absence of written employment contract; (iii) absence of social security contribution. Apply the first available proxy in this order and document which proxy was used. Where available sample in ocean industry cells falls below the national minimum for reliable estimation (typically n < 50 unweighted observations; follow the national statistical office's own reliability standard), suppress the informal/formal disaggregation and document the gap.
- ¶7 Contract type (permanent, temporary, seasonal)
- ¶8 Geographic location (coastal/inland, urban/rural)

¶9 See Section 3.6.2 for detailed indicator definitions.

¶10 **Step 2.2: Supplement with administrative data** Where labour force surveys do not provide adequate coverage of ocean sectors (particularly small-scale fisheries), supplement with administrative data from:

- ¶11 Fishing licence registries (see **TG-4.3 Administrative Data**)
- ¶12 Social security records
- ¶13 Establishment surveys in ocean industries
- ¶14 Port authority employment records

¶15 Ensure that supplements do not double-count individuals covered by surveys.

¶16 **Step 2.3: Compile wage and earnings data** Extract average wages by ocean industry and worker characteristics from establishment surveys or administrative payroll records. Calculate ratios to national averages to assess relative compensation levels.

4.1.3 Document distributional patterns

¶1 **Step 3.1: Household survey integration** Use household income and expenditure surveys to compile household income from ocean sources using the following three-step attribution method:

¶2 **(i) LFS-HIES linkage:** Where the labour force survey (LFS) and household income and expenditure survey (HIES) share a common household identifier or can be linked via synthetic matching (geographic stratum, household size, and head-of-household characteristics), match LFS respondents employed in ocean industries to HIES respondents and assign the corresponding wage and self-employment income components as ocean-derived.

¶3 **(ii) Income component assignment:** For matched households, attribute the proportion of self-employment income consistent with shares reported in establishment surveys for the relevant ocean industry.

DRAFT

¶4 **(iii) Imputation fallback:** Where linkage is not possible, impute ocean-derived income using average ocean sector earnings from the most recent establishment survey for the same ISIC group, applied to the number of ocean-employed household members identified from the LFS.

¶5 The 50% ocean-dependence threshold used to classify households as ocean-dependent is an analytical convention defined in Section 3.6.1. Compile also:

- ¶6 Household consumption of marine products by income group
- ¶7 Geographic distribution of ocean-derived income (coastal vs inland)

¶8 The household survey data should be processed following **TG-4.2 Survey Methods** to ensure proper weighting and variance estimation for coastal subpopulations.

¶9 **Step 3.2: Access rights inventory** Compile data on the distribution of formal access rights from administrative sources using the following tiered approach:

¶10 **(a) Primary:** Where legal authority for record linkage exists under national statistical confidentiality legislation, link fishing licence registries to civil registration or social security databases to obtain demographic characteristics (sex, Indigenous status, age) of rights holders. Compilers must review national confidentiality legislation and obtain any required approvals before initiating linkage.

¶11 **(b) Secondary:** Where administrative linkage is not legally permissible or technically feasible, conduct a sample survey of licence holders to collect demographic characteristics.

¶12 **(c) Minimum:** Where neither linkage nor survey is feasible, publish an unlinked count of licences by type and document the demographic data gap explicitly in the compilation metadata.

¶13 Regardless of tier applied, compile:

- ¶14 Number and type of fishing licences or permits
- ¶15 Quota allocation by vessel size class and ownership type
- ¶16 Marine protected area permits by user category
- ¶17 Coastal land tenure by community type

¶18 This access rights inventory provides the empirical link to the governance arrangements documented in **TG-3.7 Governance Accounts**, Section 3.3.1.

¶19 **Step 3.3: Gender-disaggregated indicators** Ensure all compiled indicators are disaggregated by sex to support gender equity analysis. Where sample sizes permit, further disaggregate by age group and geographic location to identify intersectional patterns.

4.1.4 Assess vulnerability and resilience

¶1 **Step 4.1: Compile exposure indicators** Using spatial data and census information, calculate:

- ¶2 Proportion of coastal population in flood zones, compiled using the following data-availability pathway:
  - ¶3 **(a) Primary:** Use national coastal flood hazard mapping produced by the national disaster management or meteorological agency where available and accessible under a data-sharing agreement.
  - ¶4 **(b) Secondary:** Use the proportion of population within a 10 m elevation band derived from CoastalDEM or the Copernicus Digital Elevation Model (both openly available). Apply standard GIS intersection methods against the latest census population grid.
  - ¶5 **(c) Minimum:** Use the proportion of population residing in coastal administrative units (lowest available administrative level intersecting within 10 km of the shoreline) as a proxy exposure indicator. Document the proxy used. Compilers are encouraged to establish formal data-sharing agreements with national disaster risk reduction agencies to access primary hazard data for future compilation cycles.
- ¶6 Share of local employment in ocean industries by community

DRAFT

- ¶7 Proportion of households dependent on fish for protein (from dietary surveys)

¶8 **Step 4.2: Compile sensitivity indicators** From household surveys and census data, tabulate for coastal communities:

- ¶9 Poverty rates (proportion below national poverty line)
- ¶10 Informal employment share in ocean sectors
- ¶11 Educational attainment distribution
- ¶12 Dependency ratios (population under 15 and over 64 relative to working age)

¶13 **Step 4.3: Compile adaptive capacity indicators** From administrative data and surveys, assess:

- ¶14 Social protection coverage for ocean-sector workers (from social security registries)
- ¶15 Access to financial services (bank account ownership, credit access from household surveys)
- ¶16 Livelihood diversification (proportion of households with multiple income sources)

¶17 These vulnerability and resilience indicators connect to the ecosystem condition trends documented in **TG-3.1 Asset Accounts** Section 3.5.2, allowing assessment of which communities are most at risk from environmental degradation.

¶18 **Minimum publication requirement for vulnerability outputs:** Compilers must produce a standardised communities-by-indicators matrix presenting all compiled exposure, sensitivity, and adaptive capacity indicators for each community unit. Compilers are not required to produce a composite vulnerability score. If a composite is produced, z-score normalization with equal weighting across component indicators is the default method; alternative weighting approaches may be used only if supported by documented empirical or expert-judgement justification. Any composite must be clearly labelled "experimental" in all publications and released alongside the full component indicator matrix to allow independent verification. For established composite methodologies that may be adapted, see the IPCC Climate Livelihood Index (CLI) methodology.

4.1.5 Integrate qualitative data

¶1 **Step 5.1: Design participatory assessments** Following the protocols described in Section 3.9.2 and consistent with **TG-3.6 Traditional Knowledge Accounts**, design community engagement processes to:

- ¶2 Validate quantitative findings
- ¶3 Identify culturally significant ocean values not captured in surveys
- ¶4 Document resident perceptions of wellbeing impacts from ocean management
- ¶5 Record narrative accounts from affected stakeholders

¶6 **Step 5.2: Conduct community consultations** Implement participatory assessments in selected coastal communities, ensuring adequate representation of:

- ¶7 Indigenous Peoples and traditional marine tenure holders
- ¶8 Women (often under-represented in formal consultation processes)
- ¶9 Small-scale fishers and informal sector workers
- ¶10 Youth and elders (for intergenerational perspectives)

¶11 **Step 5.3: Synthesize qualitative findings** Analyze qualitative data using a recognised thematic analysis framework, such as Braun and Clarke (2006) reflexive thematic analysis or an equivalent peer-reviewed framework. The framework used must be documented. A minimum of two independent coders must code the same dataset; intercoder reliability must be assessed (using Cohen's kappa or equivalent) and the reliability statistic reported alongside findings. Organize themes according to the wellbeing domains in Section 3.6.1 to facilitate integration with quantitative indicators. Publish qualitative findings as structured narrative annexes keyed to quantitative table identifiers (e.g., "Narrative Annex A: Community perceptions of food security — supplement to Table

DRAFT

4.5”). Where NSO capacity for qualitative analysis is insufficient, contracted specialist input (ethnographer, qualitative researcher) may be used; all contracted analytical work must be documented in the quality report and attributed in the publication.

4.1.6 Validate and publish accounts

¶1 **Step 6.1: Cross-validation with other accounts** Check consistency of social account indicators with:

- ¶2 Employment figures from **TG-3.3 Economic Activity**: Discrepancies between LFS-based and establishment survey-based ocean industry employment totals should be evaluated using the country-specific materiality thresholds set in the national statistical office’s own quality standard, documented as set out in **TG-0.7 Quality Assurance**. Discrepancies that exceed the country’s established materiality level require a documented reconciliation note in the Step 6.2 technical documentation, explaining the probable source of the divergence and the compiler’s assessment of which estimate is more reliable. In developing-economy contexts, LFS-establishment survey discrepancies of 10–20% are common, particularly for informal-sector employment, and do not necessarily indicate error — the reconciliation note should explain the likely cause.
- ¶3 Spatial distributions relative to ecosystem accounting areas in **TG-3.1 Asset Accounts**: Where no common spatial reference frame exists, qualitative directional alignment (i.e., confirming that social account coverage areas broadly correspond to ecosystem accounting zones) is sufficient.
- ¶4 Access rights data with governance frameworks in **TG-3.7 Governance Accounts**

¶5 **Step 6.2: Document data sources and methods** Prepare technical documentation describing:

- ¶6 Data sources used and their coverage
- ¶7 Estimation methods for filling data gaps
- ¶8 Quality assessment following **TG-0.7 Quality Assurance**
- ¶9 Known limitations and areas requiring methodological development

¶10 **Step 6.3: Disseminate accounts** Publish social accounts with supporting narrative that:

- ¶11 Explains key findings for each wellbeing domain
- ¶12 Highlights distributional patterns relevant to equity analysis
- ¶13 Identifies vulnerable populations requiring policy attention
- ¶14 Links findings to relevant SDG targets and indicators

4.2 Data sources

¶1 Social accounts draw on diverse data sources including:

¶2 **Household surveys:** Labour force surveys, living standards surveys, and specialized coastal community surveys provide individual and household-level data on income, employment, consumption, and subjective wellbeing. See **TG-4.2 Survey Methods** for guidance on ocean-specific survey modules and weighting procedures for coastal populations.

¶3 **Administrative records:** Social protection records, fishing licenses, maritime worker registrations, and educational records provide population-level administrative data. See **TG-4.3 Administrative Data** for guidance on accessing and using administrative data.

¶4 **Community consultations:** Participatory assessments and stakeholder engagement processes generate qualitative data and validate quantitative findings.

¶5 **Census data:** Population and housing censuses provide baseline demographic data for coastal communities.

¶6 **Enterprise surveys:** Establishment surveys in ocean sectors provide employment and working condition data from the employer perspective.

DRAFT

¶7 **Subjective wellbeing surveys:** Where a national wellbeing or living conditions survey exists, compilers should request inclusion of a coastal supplement module. The module should include at minimum the three OECD core subjective wellbeing questions (life evaluation using a Cantril ladder, positive affect, and negative affect) and one ocean-specific domain satisfaction item (e.g., "How satisfied are you with the state of the ocean and marine resources in your area?"). A reference sample module of 5-8 items suitable for coastal contexts is available from GOAP. Where no national survey is available, compilers may commission a standalone coastal supplement survey; sample size for each coastal subregion should be determined using Cochran's formula ($n_0 = Z^2 \cdot p \cdot (1-p)/e^2$), with precision level (e), confidence level (Z), and expected prevalence (p) set in accordance with national statistical standards. No universal minimum sample size is prescribed, as adequate size depends on expected prevalence, margin of error, confidence level, and population size; compilers should document all parameters used. For guidance on domain-level sample sizing, see *Household Sample Surveys in Developing and Transition Countries*, Chapter II (UNSD, 2005). See also OECD Guidelines on Measuring Subjective Well-being (2025 Update).

¶8 Data quality considerations are particularly important for social accounts, given the diversity of sources and the frequent reliance on survey data that may have limited sample sizes in coastal communities. Compilers should assess the following quality dimensions for each data source: coverage (whether the source adequately represents ocean-dependent populations), timeliness (whether the data reflect current conditions), coherence (whether data from different sources can be reconciled), and accuracy (whether measurements are subject to known biases, such as under-reporting of informal employment or subsistence activities). The quality assurance procedures described in **TG-0.7 Quality Assurance** apply to social accounts and should be adapted to address these source-specific considerations.

4.3 Integration with other accounts

¶1 Social accounts connect to multiple other components of ocean accounting:

- ¶2 **Economic accounts** (**TG-3.3 Economic Activity**): Employment and income indicators in social accounts complement value-added and output measures in economic accounts. Compilers should ensure consistent use of industry classifications across both account types.
- ¶3 **Ecosystem services accounts** (**TG-2.4 Ecosystem Goods and Services**): Cultural services documented in ecosystem accounts relate to non-material wellbeing in social accounts
- ¶4 **Governance accounts** (**TG-3.7 Governance Accounts**): Governance frameworks shape access, equity, and adaptive capacity documented in social accounts. Governance accounts document the rules; social accounts document the outcomes.
- ¶5 **Traditional knowledge accounts** (**TG-3.6 Traditional Knowledge Accounts**): Qualitative approaches in social accounts connect to documentation of traditional knowledge systems
- ¶6 **Condition accounts** (**TG-2.1 Biophysical Indicators**, **TG-3.1 Asset Accounts** Section 3.5.2): Ecosystem condition affects both vulnerability and the capacity of ecosystems to support wellbeing
- ¶7 **Ecosystem accounts** (**TG-3.1 Asset Accounts**): Ecosystem degradation patterns relate to social vulnerability

4.4 Challenges and limitations

¶1 Social accounting for ocean contexts faces several methodological challenges:

¶2 **Attribution:** Isolating the specific contribution of ocean factors to wellbeing outcomes that are influenced by many determinants

¶3 **Data availability:** Limited availability of ocean-specific social data, particularly for small-scale sectors and informal activities

DRAFT

¶4 **Spatial matching:** Aligning social data (often collected for administrative units) with marine spatial units used in environmental accounts

¶5 **Comparability:** Ensuring comparability across contexts when social conditions vary substantially between countries and communities

¶6 **Subjectivity:** Incorporating qualitative and subjective dimensions while maintaining analytical rigour

¶7 Compilers should document data sources, methods, and limitations transparently to support appropriate interpretation and use of social account information.

4.5 Worked Example: Community Dependency and Distributional Analysis

¶1 This section extends the employment account from v3 (Section 4.4) with a distributional analysis for a hypothetical coastal community, demonstrating how social accounts support the decision use-cases outlined in Section 3.5. All figures are illustrative and designed to demonstrate the analytical structure; actual compilations would draw on household surveys, administrative records, and participatory assessments as described in Section 4.1 and 4.2.

4.5.1 Scenario: Coastal fishing community distributional profile

¶1 **Setting:** A hypothetical coastal community of 25,000 persons (6,250 households) in a Pacific Island State. The community is classified as "high ocean dependency" based on the dependency assessment described below.

4.5.2 Dependency assessment

¶1 The first analytical step assesses the community's dependence on ocean resources across multiple dimensions:

¶2 *Table 4.1: Ocean dependency indicators for hypothetical coastal community*

Dependency dimension	Community value	National average	Ratio
Employment in ocean industries (% of labour force)	38%	12%	3.2
Household income from ocean (% of total)	42%	15%	2.8
Fish consumption (kg/capita/year)	65	28	2.3
Households with fishing access rights (%)	45%	8%	5.6

DRAFT

¶3 The community shows substantially higher ocean dependency than the national average across all four dimensions. This multi-dimensional dependency profile indicates elevated vulnerability to ocean environmental and governance changes. Employment dependency of 38% places this community in the upper decile nationally, suggesting that shocks to ocean industries would have severe local economic impacts.

4.5.3 Income distribution by ocean dependency

¶1 The second analytical step disaggregates household income by ocean dependency status and income quintile, revealing distributional patterns:

¶2 *Table 4.2: Household income by ocean dependency and income quintile (local currency units)*

Income quintile	Ocean-dependent households (n=2,813)	Non-ocean households (n=3,437)	Ratio
Q1 (lowest 20%)	8,500	12,000	0.71
Q2	15,000	18,000	0.83
Q3	22,000	24,000	0.92
Q4	32,000	35,000	0.91

Income quintile	Ocean-dependent households (n=2,813)	Non-ocean households (n=3,437)	Ratio
Q5 (highest 20%)	55,000	62,000	0.89
Mean	**26,500**	**30,200**	**0.88**

¶3 Ocean-dependent households (defined as those deriving >50% of income from ocean industries or subsistence fishing) have lower incomes than non-ocean households across all quintiles. The gap is most pronounced for the lowest quintile (ocean-dependent households earn only 71% of non-ocean household income), indicating that ocean dependence is associated with poverty risk.

¶4 *Table 4.3: Poverty rates by ocean dependency status*

Category	Households below poverty line	Poverty rate
Ocean-dependent households	785	27.9%
Non-ocean households	515	15.0%
Total community	**1,300**	**20.8%**

¶5 The poverty rate among ocean-dependent households (27.9%) is nearly double that of non-ocean households (15.0%). This distributional pattern has direct implications for just transition planning (Section 3.5.3): policies that reduce access to ocean resources without providing alternative livelihoods will disproportionately harm already-poor households.

4.5.4 Employment characteristics by gender and formality

¶1 The third analytical step examines employment characteristics in the community's main ocean sector (small-scale fishing):

¶2 *Table 4.4: Small-scale fishing employment characteristics (earnings in local currency units)*

Characteristic	Male	Female	Total
Total fishing employment	1,850	450	2,300
Formal employment	370 (20%)	45 (10%)	415 (18%)
Informal employment	1,480 (80%)	405 (90%)	1,885 (82%)
Mean annual earnings (formal)	28,000	22,000	27,000
Mean annual earnings (informal)	16,500	11,000	15,200
Social protection coverage	22%	8%	19%

DRAFT

¶3 *Note: Total column earnings figures are rounded to the nearest 100. Exact weighted means are 27,350 (formal) and 15,320 (informal).*

¶4 The employment profile reveals three distributional concerns:

1. ¶5 **High informality:** 82% of fishing employment is informal, meaning workers lack social protection, occupational safety coverage, and income stability. This is substantially higher than the national informal employment rate of 40%.
2. ¶6 **Gender gaps:** Women constitute only 20% of fishing employment but 90% of female fishing workers are informal, compared to 80% of male workers. Women's earnings in both formal and informal fishing are 21-33% lower than men's.
3. ¶7 **Low social protection:** Only 19% of fishing workers have social protection coverage, compared to 64% nationally. This leaves the community highly vulnerable to income shocks.

4.5.5 Food security and nutrition

¶1 The fourth analytical step assesses the community's dependence on marine protein for food security:

¶2 *Table 4.5: Dietary composition and food security indicators*

Indicator	Community value	National average
Fish consumption (kg/capita/year)	65	28
Share of protein from fish (%)	72%	38%
Dietary diversity score (0–9 scale)	4.8	5.9
Households food-secure year-round (%)	68%	82%
Households experiencing seasonal food shortage (%)	32%	18%

¶3 The community derives 72% of protein from fish, more than double the national average and indicative of high nutritional dependence on marine resources. However, dietary diversity is lower than the national average (4.8 vs 5.9), and 32% of households experience seasonal food shortages (compared to 18% nationally). This pattern suggests that while fish provides critical protein, the community is vulnerable to disruptions in fisheries access or marine resource availability.

¶4 Disaggregating by income quintile reveals that food insecurity is concentrated among lower-income ocean-dependent households:

¶5 *Table 4.6: Food security by income quintile and ocean dependency*

Income quintile	Ocean-dependent HH food insecure	Non-ocean HH food insecure	Total food insecure
Q1 (lowest 20%)	58%	42%	52%
Q2	35%	22%	28%
Q3	18%	12%	15%
Q4	8%	5%	6%
Q5 (highest 20%)	3%	2%	2%

¶6 More than half (58%) of ocean-dependent households in the lowest income quintile experience food insecurity, compared to 42% of non-ocean households in the same quintile. This indicates that ocean dependence compounds poverty-related food insecurity, likely because fishing income is volatile and subsistence catches are subject to seasonal and environmental variability.

DRAFT

4.5.6 Access rights distribution

¶1 The fifth analytical step documents how formal fishing access rights are distributed:

¶2 *Table 4.7: Distribution of fishing access rights*

Licence type	Number of licences	Held by women	Held by Indigenous community members
Commercial fishing (offshore)	45	2 (4%)	8 (18%)
Commercial fishing (inshore)	180	18 (10%)	95 (53%)
Small-scale fishing	1,850	280 (15%)	1,200 (65%)
Subsistence fishing	2,800	1,120 (40%)	2,450 (88%)
Total	**4,875**	**1,420 (29%)**	**3,753 (77%)**

¶3 Access rights are highly stratified: commercial offshore licences (which provide access to higher-value fish stocks) are held almost exclusively by men (96%) and disproportionately by non-Indigenous community members (82%), while subsistence licences (which provide access only to low-value nearshore areas) are held predominantly by Indigenous community members (88%) and have much higher women's representation (40%).

¶4 This distributional pattern reflects the governance arrangements documented in **TG-3.7 Governance Accounts** Section 3.3.1. The social account documents the outcome — that commercial fishing opportunities are concentrated among a small, predominantly male, non-Indigenous group — while the governance account would document the licensing rules and allocation criteria that produce this outcome.

4.5.7 Analytical synthesis for decision support

¶1 The distributional profile compiled above supports the three decision use-cases identified in Section 3.5:

¶2 **Equity assessment (Section 3.5.1):**

- ¶3 Current fishing licence allocation concentrates commercial access among non-Indigenous men, while Indigenous community members and women hold predominantly lower-value subsistence licences
- ¶4 Reform options: Introduce preferential licensing for Indigenous fishers, gender quotas for commercial licences, or community-based allocation that reserves commercial access for local residents

¶5 **Vulnerability analysis (Section 3.5.2):**

- ¶6 High ocean dependency (38% employment, 42% income) combined with high informality (82%), low social protection (19%), and nutritional dependence on fish (72% of protein) indicates extreme vulnerability to marine resource decline or governance changes
- ¶7 Priority interventions: Extend social protection to informal fishing workers, establish emergency food reserves, invest in livelihood diversification programs

¶8 **Just transition planning (Section 3.5.3):**

- ¶9 If fisheries management requires catch reductions (e.g., due to stock decline), impacts will fall heavily on already-poor ocean-dependent households (27.9% poverty rate)
- ¶10 Transition support should include: income support during adjustment period, retraining for alternative livelihoods, preferential access to emerging ocean sectors (e.g., marine tourism, aquaculture), and strengthened food assistance for households losing subsistence fishing access

¶11 This worked example demonstrates how social accounts compiled following the procedures in Section 4.1 can generate the integrated wellbeing, equity, and vulnerability data needed to inform ocean management decisions.

DRAFT

5. Uncertainties and Risks

¶1 Social Accounts, as conceptualised in this circular, represent a genuinely new domain within national accounting frameworks. The theoretical foundations developed in the preceding sections draw on established international statistical standards, but the application of a stocks-and-flows architecture to social phenomena in ocean contexts has not yet been standardised at the international level, and no single composite methodology or index for measuring social conditions in ocean accounting has yet achieved international statistical endorsement. The indicators, categories, and methods presented here reflect the best available conceptual guidance at the time of publication, grounded in pilot experience from Costa Rica, Belize, Mozambique, and the Maldives [17]. This provisional character is not a weakness to be concealed but an honest acknowledgement of where the field stands, and it carries a structural implication: Social Accounts must be designed from the outset as learning systems, not fixed instruments. The definition offered in this circular is accordingly a living definition, one that accommodates evolving evidence, advancing methodologies, and insights that can only be generated through practice [12]. Practitioners should build in mechanisms for reflexive review, including regular re-evaluation of category boundaries and indicator sets against community realities. The methodological guidance in subsequent circulars will specify

phased implementation approaches for contexts where data availability, institutional capacity, or funding constraints require a staged rather than comprehensive approach to Social Accounts compilation.

¶2 Beyond methodological limitations, Social Accounts carry inherent political and structural risks that are not reducible to data problems and that must be named directly in any theoretically honest account of the framework's limitations. The most significant of these is the risk of co-option: the possibility that accounting frameworks designed to make inequities visible are instead deployed to justify existing resource allocations, characterise ocean governance as more equitable than it is, or satisfy international reporting requirements without changing any of the underlying power relationships that produce inequality. Visibility without redistribution of power changes nothing. A community whose dependence on subsistence fishing is carefully documented in a Social Account but whose access to fishing grounds is subsequently curtailed by a marine protected area established without their meaningful participation in the decision has not been served by the accounting exercise. A related risk concerns the selection of categories and indicators: those who design accounting frameworks exercise significant power over what is counted and what is not, and the finalisation of standard categories therefore requires transparent governance, explicit mechanisms for community review, and clear accountability for how and by whom those decisions are made [17]. Social Accounts Working Group processes, such as those that contributed to the development of this circular, represent one mechanism for distributing decision-making authority across a broader constituency of expertise and lived experience, but they do not substitute for direct community authority over account design in the localities where accounts will be applied.

¶3 A risk that is closely related to the political economy of accounting but operates at the methodological level concerns the aggregation of social data across heterogeneous populations. Aggregate indicators can mask precisely the inequalities that Social Accounts are designed to document. When data on ocean-dependent employment, food security, or participation in governance are reported as community-level averages, they produce a picture in which the median household stands in for all households, rendering women's unpaid contributions, young people's precarious livelihoods, persons with disabilities' systematic exclusion from data collection processes, and Indigenous peoples' distinctive relationships to marine resources simultaneously invisible within the very framework intended to make them visible [26]. This is not a technical error but a design choice, and it must be recognised as such. The structural response is disaggregation. Social Accounts must be designed to report stock and flow indicators by gender (or sex), age group, indigeneity, ethnicity, disability status, and geographic territory wherever is appropriate and permitted by data. Where disaggregated data do not yet exist, that absence is itself a finding of the accounting process. It should be named explicitly and used to inform targeted data collection, rather than being absorbed into an aggregate that implies false completeness. The GEDSI analysis from the Costa Rica Social Accounts pilot demonstrates the depth of structural inequality that exists within ostensibly homogeneous coastal community categories, and provides an instructive reference for practitioners developing disaggregation plans [26].

¶4 One of the most serious risks associated with Social Accounts concerns the governance of data about communities rather than data produced by institutions. When Social Accounts document livelihood dependence, resource access, land tenure, cultural practices, or the composition of community governance structures, they generate information that can expose vulnerable populations to harm if published without appropriate safeguards. For communities that face political marginalisation, land dispossession, or persecution, the visibility that Social Accounts offer is not inherently protective, and may in some contexts be actively dangerous. The CARE Principles for Indigenous data governance, which affirm Collective Benefit, Authority to Control, Responsibility, and Ethics [25], provide a framework for thinking through these risks in a principled way, and should be embedded in Social Accounts governance arrangements from the outset. Social Accounts that document Indigenous, Traditional, and Local Knowledge must be governed in accordance with Free, Prior, and Informed Consent: communities must determine whether their knowledge enters the ac-

DRAFT

counts, on what terms, at what level of detail, and with what restrictions on access and use [17]. Community data sovereignty, the right of communities to own, control, and govern data about themselves, is not an optional feature of responsible Social Accounts practice but a condition of the framework's ethical and political legitimacy. Data governance protocols, including decisions about who can access what data and under what conditions, should be established before compilation begins.

¶5 Two limitations inherent to the theoretical architecture of Social Accounts warrant particular attention as epistemological rather than merely technical problems. The first is the attribution challenge: isolating the specific contribution of ocean factors to wellbeing outcomes that are simultaneously shaped by many determinants. A coastal household may experience food insecurity because of a decline in fish stocks, because of reduced household income from non-ocean sources, because of domestic care responsibilities that constrain participation in fishing, or because of changes in food prices unrelated to marine conditions. Social Accounts can document each of these dimensions, but the accounting architecture cannot determine the relative weight of the ocean's contribution to wellbeing with the same precision that economic accounts can attribute value-added to a specific sector. This reflects the genuine complexity of social causation, and it should temper claims about what Social Accounts can conclusively establish. The second epistemological limitation concerns spatial matching. Social data are typically collected for administrative units including census districts, municipalities, and health zones, whose boundaries do not correspond to the marine spatial units used in environmental and economic ocean accounts. Social lives are not organised around marine spatial boundaries, and any method for aligning social data to ocean spatial frameworks will involve approximation and boundary decisions that affect who and what is captured. These decisions should be documented transparently alongside the accounts to which they give rise.

¶6 Several methodological risks require careful management at the compilation stage. Double counting is a recurrent concern in integrated accounting frameworks: the boundary between Social Accounts and economic accounts requires consistent definition to prevent the same activity from appearing in both, particularly for activities that sit at or near the SNA production boundary, including subsistence fishing, informal gleaning, and community food preparation. Practitioners should document these boundary decisions explicitly and cross-reference against existing economic account categories before finalising social flow indicators [12]. A related boundary problem concerns geographic scope: how the coastal zone is defined determines who is included in Social Accounts coverage, and different definitions can produce systematically different pictures of ocean dependence, vulnerability, and benefit distribution. Where multiple definitions are in use within a country, the Social Account should document the definition applied and its implications for coverage. A further risk concerns indicator design: when specific metrics are over-emphasised relative to the social phenomena they are intended to represent, the process of measurement can produce misleading conclusions or perverse incentives. Measuring participation rates in governance processes may register apparent increases in engagement that do not correspond to any increase in actual influence over decisions. Indicator selection should therefore be guided by explicit consideration of what each indicator can and cannot capture, with particular care given to avoiding over-reliance on metrics whose convenience of collection may be inversely related to their theoretical adequacy.

¶7 Social Accounts that are compiled across multiple time periods to track trends in social conditions, asset stocks, and community wellbeing depend on institutional arrangements that protect long-term data continuity against political volatility. Governments change, policy priorities shift, and the social dimensions of ocean governance are frequently contested. Without institutional safeguards, time-series data that document inequality, community dependence, or governance failures may be discontinued, selectively released, or re-categorised in ways that disrupt comparability and undermine accountability. The principle of institutional independence for statistical production, which underpins the credibility of national accounts more broadly, applies with particular force to Social Accounts, given that the communities they document are frequently those with the least in-

DRAFT

stitutional power to advocate for their continued visibility. Anchoring Social Accounts within national statistical systems, as recommended in the preceding sections, provides the most durable protection against political disruption, while also maintaining the interoperability with the System of National Accounts and the System of Environmental-Economic Accounting that gives Social Accounts their analytical value. Where national statistical capacity is limited, regional or international partnerships can provide additional institutional stability for the development and maintenance of Social Accounts over time.

6. Acknowledgements

¶1 **Authors:** Rebecca Shellock, Maria Alarcon Blazquez, Hadi Yoga Dewanto, Philip James, Ben Milligan (University of New South Wales)

¶2 **Contributors:** Annisya Rosdiana (Rekam Nusantara Foundation), Andrea Robles Jirón (BIOMATEC), Alexandra Rodríguez-Rodríguez (RMIT University), Armyanda Tussadiah (Yayasan Masyarakat dan Alam Nusantara), Bernadette Snow (Scottish Association for Marine Science), Chandrasekhara Sarma (Individual), Dorota Kolbuk (University College Dublin), Elena Mengo (Cefas — Centre for Environment Fisheries and Aquaculture Science), Emily M. Ogier (Institute for Marine and Antarctic Studies, University of Tasmania), Jenny Angélica Quijozaca Quijosaca (Asamblea Comunitaria San Cristóbal), Jin Tanaka (UNISC), Kafayat Fakoya, Karina M. Higa (Empathea Blue Ltda), Khesyia Abigail Makhas (Mangrove Nusantara/MATA Nusantara), Laura Friedrich (Norwegian Institute for Water Research, NIVA), Philippa McKay (The Nature Conservancy), Rachel Thoms (World Resources Institute), Ria Arinda (BPS — Statistics Indonesia), Sara Driscoll (National Oceanography Centre), Scott Schrempf (Dalhousie University), Shehu Latunji Akintola (Lagos State University), Tiziana Luisetti (Cefas).

7. References

¶1 [1] Hoekstra, R. (2020) 'SNA and beyond: towards a broader accounting framework that links the SNA, SDGs and other global initiatives', *Statistical Journal of the IAOS*, 36(3), pp. 657-675.

¶2 [2] Cook, D., Kaji, T.B. and Davíðsdóttir, B. (2023) 'An assessment of the scope and comprehensiveness of well-being economy indicator sets: the cases of Iceland, Scotland and New Zealand', *Ecological Economics*, 205, p. 107728.

¶3 [3] United Nations Statistics Division (2025) *System of National Accounts 2025*. New York: United Nations.

¶4 [4] Shellock, R.J., Spillias, S., James, P.A.S., Bridgland, J., Fernandez-Abila, C.J., Alarcon Blazquez, M., Gacutan, J. and Thoms, R. (in review) 'Putting people at the heart of ocean decision-making: the integration of social considerations in ocean accounting'.

¶5 [5] Shellock, R.J., Fernandez-Abila, C.J., Spillias, S., James, P.A.S., Bridgland, J., Alarcon Blazquez, M., Gacutan, J., Thoms, R., Bezabih, M. and Schramm, A. (in preparation) 'Making communities visible: integrating social dimensions in land and freshwater accounting'.

¶6 [6] Loureiro, T.G., Milligan, B., Gacutan, J., Adewumi, I.J. and Findlay, K. (2023) 'Ocean accounts as an approach to foster, monitor, and report progress towards sustainable development in a changing ocean: the Systems and Flows Model', *Marine Policy*, 154.

¶7 [7] Failler, P., Liu, J., Lallemand, P. and March, A. (2023) 'Blue accounting approaches in the emerging African Blue Economy context', *Journal of Sustainability Research*, 5.

¶8 [8] Boswell, R. (2023) 'Prioritizing the culture metric for transformative ocean management in South Africa', *Ecosystems and People*, 19.

DRAFT

¶9 [9] Loureiro, T.G., Gacutan, J., Milligan, B.M., Praphotjanaporn, T. and Findlay, K. (2022) 'Every account counts for sustainable development: lessons from the African CoP to implement ocean accounts in the Western Indian Ocean region', *Western Indian Ocean Journal of Marine Science*, pp. 139-165.

¶10 [10] Mullin, K., Mitchell, G., Nawaz, N.R. and Waters, R.D. (2018) 'Natural capital and the poor in England: towards an environmental justice analysis of ecosystem services in a high income country', *Landscape and Urban Planning*, 176, pp. 10-21.

¶11 [11] Burnside, M. (in preparation) *How Ocean Accounts Can Support the Reduction in Poverty and Vulnerability in Ocean Dependent Communities*. Report by the Global Ocean Accounts Partnership / Centre for Sustainable Development Reform.

¶12 [12] Shellock, R.J. and James, P.A.S. (2024) *Social Accounts Briefing Paper*. Report by the Global Ocean Accounts Partnership / Centre for Sustainable Development Reform.

¶13 [13] Shellock, R.J. and James, P.A.S. (2025) *Towards Social Accounts: Rethinking How We Understand and Use Social Information*. Briefing paper by the Global Ocean Accounts Partnership / UNSW Centre for Sustainable Development Reform.

¶14 [14] Hollaway, E., Northrop, E., Alarcon Blazquez, M., Bridgland, J., Schramm, A., Shellock, R., Gacutan, J. and Loureiro, T.G. (2024) *Ocean Accounts for Sustainable Ocean Plans: Enabling Decision-makers to Measure Progress*.

¶15 [15] United Nations, European Commission, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development and World Bank (2014) *System of Environmental-Economic Accounting 2012: Central Framework*. New York: United Nations.

¶16 [16] United Nations, European Commission, Food and Agriculture Organization of the United Nations, Organisation for Economic Co-operation and Development and World Bank (2021) *System of Environmental-Economic Accounting: Ecosystem Accounting (SEEA EA)*. New York: United Nations.

¶17 [17] Shellock, R.J., Thoms, R., James, P.A.S., Loureiro, T.G., Rosado, C., Swaleh, M., Kurniati, E., Lecuyer, O., Contreras, C., Arinda, R., Oleson, K.L.L., Buchary, E.A., Rosdiana, A., Grimsrud, K.M., Chen, W., Finau, G., Chambo, J.J., Alarcon, M., de Wolf, N., Quijozaca, J.A., Hidayat, R.H.M., Carter, J., Driscoll, S., McLeod, R., Ahmad, M., Sulaiman, A.M., Murunga, M., Hill, A.L., Agung, F., Teoh, M. and Cappabianca, R. (2025) 'Social Accounts for the ocean: a path to inclusive and equitable ocean decision-making', *Environmental Science and Policy*, 173, 104221.

¶18 [18] Normyle, A., Vardon, M. and Doran, B. (2023) 'Aligning Indigenous values and cultural ecosystem services for ecosystem accounting: a review', *Ecosystem Services*, 59, p. 101502.

¶19 [19] Normyle, A., Vardon, M. and Doran, B. (2022) 'Ecosystem accounting and the need to recognise Indigenous perspectives', *Humanities and Social Sciences Communications*, 9(1), pp. 1-7.

¶20 [20] Finau, G., Jarvis, D., Stoeckl, N., Larson, S., Grainger, D., Douglas, M., Barrowei, R., Coleman, B., Groves, D., Hunter, J. and Lee, M. (2023) 'Accounting for Indigenous cultural connections to land: insights from two Indigenous groups of Australia', *Accounting, Auditing and Accountability Journal*, 36(9), pp. 370-389.

¶21 [21] Normyle, A., Doran, B., Mathews, D., Melbourne, J. and Vardon, M. (2024) 'Adapting ecosystem accounting to meet the needs of Indigenous living cultural landscapes: a case study from Yawuru Country, northern Australia', *Global Environmental Change*, 87, p. 102876.

¶22 [22] Normyle, A., Doran, B., Vardon, M., Mathews, D., Melbourne, J. and Althor, G. (2022) 'An Indigenous perspective on ecosystem accounting: challenges and opportunities revealed by an Australian case study', *Ambio*, 51, pp. 2227-2239.

DRAFT

¶23 [23] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2018) *Summary for Policymakers of the Regional Assessment Report on Biodiversity and Ecosystem Services for the Americas*. Bonn: IPBES Secretariat.

¶24 [24] Intergovernmental Panel on Climate Change (2022) *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

¶25 [25] Carroll, S.R., Garba, I., Figueroa-Rodríguez, O.L., Holbrook, J., Lovett, R., Materechera, S., Parsons, M., Raseroka, K., Rodriguez-Lonebear, D., Rowe, R., Sara, R., Walker, J.D., Anderson, J. and Hudson, M. (2020) 'The CARE Principles for Indigenous Data Governance', *Data Science Journal*, 19(1), p. 43.

¶26 [26] BTC GEDSI Analysis (2025) Preliminary Findings: GEDSI Analysis. Costa Rica Social Accounts Pilot. Global Ocean Accounts Partnership.

FOOTNOTES

1. ¶1 System of National Accounts 2025, Preface, para. B.
2. ¶2 System of National Accounts 2025, Preface, Section A (Introduction).
3. ¶3 SEEA Ecosystem Accounting, para. 6.51.
4. ¶4 SF-MST, Glossary, definition of "Employment".
5. ¶5 United Nations, 2030 Agenda for Sustainable Development, SDG Target 2.3.
6. ¶6 SEEA for Agriculture, Forestry and Fisheries, para. 2.
7. ¶7 United Nations, 2030 Agenda for Sustainable Development, SDG Target 8.9.
8. ¶8 SF-MST, Table 5.3.
9. ¶9 United Nations, Transforming our world: the 2030 Agenda for Sustainable Development, SDG Target 14.7.
0. ¶10 United Nations, Global indicator framework for SDGs, Indicator 14.7.1.
1. ¶11 SF-MST, para. 5.66.
2. ¶12 United Nations, Global indicator framework for SDGs, Indicator 8.8.1.
3. ¶13 United Nations, Global indicator framework for SDGs, Indicator 8.3.1.
4. ¶14 SF-MST, para. 5.80.
5. ¶15 United Nations, 2030 Agenda for Sustainable Development, SDG Target 8.8.
6. ¶16 Adapted from SF-MST, para. 5.69, and ILO Decent Work Indicators: Concepts and Definitions.
7. ¶17 OECD, Guidelines on Measuring Subjective Well-being, 2013.
8. ¶18 SF-MST, para. 5.46.
9. ¶19 System of National Accounts 2025, Chapter 34 (Measuring well-being), sections on household distributional analysis. See also Preface, Section B (New features) on wellbeing and sustainability.
0. ¶20 UNWTO, Global Report on Women in Tourism - Second Edition, 2019, as cited in SF-MST para. 5.71.
1. ¶21 TNFD Recommendations, Box 1.
2. ¶22 United Nations, 2030 Agenda for Sustainable Development, SDG Target 14.b.
3. ¶23 United Nations, Global indicator framework for SDGs, Indicator 14.b.1.
4. ¶24 UNCLOS, Article 140.
5. ¶25 United Nations, 2030 Agenda for Sustainable Development, SDG Target 15.6.
6. ¶26 IPCC, 2022, Annex II: Glossary, Climate Change 2022: Impacts, Adaptation and Vulnerability.
7. ¶27 United Nations, 2030 Agenda for Sustainable Development, SDG Target 1.5.
8. ¶28 United Nations, 2030 Agenda for Sustainable Development, SDG Target 14.2.
9. ¶29 SF-MST, para. 1.58.
0. ¶30 TNFD Recommendations, Executive Summary.
1. ¶31 United Nations, Global indicator framework for SDGs, Indicator 1.3.1.
2. ¶32 IPCC, 2022, Annex II: Glossary, definition of "Resilience".
3. ¶33 TNFD Recommendations, Strategy C.
4. ¶34 SEEA Ecosystem Accounting, para. 6.51.
5. ¶35 TNFD Recommendations, Governance C.
6. ¶36 SF-MST, Chapter 5.4.
7. ¶37 SF-MST, para. 5.46.

DRAFT

DRAFT

Traditional Knowledge

Incorporates traditional knowledge into ocean accounts, applying principles for respectful engagement with Indigenous Peoples and Local Communities (IPLCs).

Version 0.7.3 **Status** Draft **Stability** Emerging

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

OUTCOME

After completing this Circular, readers will be able to incorporate traditional knowledge into ocean accounts, applying principles for respectful engagement with Indigenous Peoples and Local Communities (IPLCs), approaches for integrating traditional knowledge with scientific data, and the ethical frameworks that must govern such integration. The guidance recognises that methods for incorporating traditional knowledge into statistical frameworks are still developing and require particular sensitivity to cultural protocols, intellectual property rights, and the self-determination of knowledge holders.

Important Note: This Circular addresses an emerging and sensitive area of ocean accounting practice. Traditional knowledge systems are diverse, context-specific, and embedded in cultural frameworks that may not align neatly with standardised accounting approaches. The guidance provided here should be understood as provisional principles rather than prescriptive methods, and practitioners should expect that approaches will continue to evolve as experience accumulates and as Indigenous Peoples and Local Communities articulate their own frameworks for knowledge sharing. Each engagement with traditional knowledge holders must be tailored to the specific cultural context and conducted with respect for the rights and protocols of knowledge-holding communities. No single set of guidelines can substitute for the sustained, context-sensitive relationship building that ethical traditional knowledge work demands.

CONTENTS

1. Outcome 3
1.1 Why traditional knowledge matters for ocean accounting 3
2. Requirements 4
3. Guidance Material 4
3.1 Principles for Engagement 4
3.2 Knowledge Integration Approaches 7
3.3 Ethical Considerations 10
3.4 Compilation Procedure for Integrating Traditional Knowledge 12
3.5 Cultural Services and Traditional Knowledge 16
4. Worked Example 19
4.1 Scenario: Mangrove cultural value assessment in a hypothetical Pacific Island community 20
4.2 FPIC process steps applied to the assessment 20
4.3 Cultural services account template 20
4.4 Traditional knowledge inputs to condition accounts 21
4.5 Benefit-sharing and capacity building outcomes 22
4.6 Key observations from the worked example 22
5. Compilation Considerations 23
5.1 Capacity and resources 23
5.2 Limitations and uncertainties 23
5.3 Reporting and attribution 24
5.4 Connections with related circulars 24
Implementation Considerations 24
6. References and Further Reading 24
Footnotes 25

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Traditional Knowledge (2026) (GOAP Technical Guidance on Ocean Accounting, TG-3.6, v0.7.3). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-3/3-6-traditional-knowledge/

DRAFT

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

1. Outcome

¶1 After completing this Circular, readers will be able to incorporate traditional knowledge into ocean accounts, applying principles for respectful engagement with Indigenous Peoples and Local Communities (IPLCs), approaches for integrating traditional knowledge with scientific data, and the ethical frameworks that must govern such integration. The guidance recognises that methods for incorporating traditional knowledge into statistical frameworks are still developing and require particular sensitivity to cultural protocols, intellectual property rights, and the self-determination of knowledge holders.

¶2 **Important Note:** This Circular addresses an emerging and sensitive area of ocean accounting practice. Traditional knowledge systems are diverse, context-specific, and embedded in cultural frameworks that may not align neatly with standardised accounting approaches. The guidance provided here should be understood as provisional principles rather than prescriptive methods, and practitioners should expect that approaches will continue to evolve as experience accumulates and as Indigenous Peoples and Local Communities articulate their own frameworks for knowledge sharing. Each engagement with traditional knowledge holders must be tailored to the specific cultural context and conducted with respect for the rights and protocols of knowledge-holding communities. No single set of guidelines can substitute for the sustained, context-sensitive relationship building that ethical traditional knowledge work demands.

1.1 Why traditional knowledge matters for ocean accounting

¶1 Ocean accountants need to engage with traditional knowledge for three principal reasons:

¶2 **First, gap-filling in data-sparse regions.** Many coastal and marine areas lack adequate scientific monitoring infrastructure, particularly in remote islands, polar seas, and developing coastal states. Traditional knowledge holders who have sustained relationships with these environments over generations hold observational knowledge that can inform ecosystem condition assessments, document historical baselines, and identify environmental changes not captured by sparse monitoring networks. For example, Indigenous observations of sea ice dynamics in Arctic marine areas have extended observational records by decades, whilst Pacific Island community knowledge of reef condition provides spatially detailed information unavailable from satellite remote sensing alone[1]. This gap-filling function is particularly relevant to ecosystem condition accounts (**TG-3.1 Asset Accounts** Section 3.5.2) and biophysical indicator selection (**TG-2.1 Aggregate Biophysical Indicators of Environmental State**).

¶3 **Second, validation and contextualisation of scientific data.** Traditional knowledge provides independent lines of evidence that can validate or contextualise remote sensing classifications, model outputs, and short-term field surveys. When traditional ecological knowledge converges with scientific monitoring, confidence in both knowledge systems is strengthened. Divergence identifies areas that warrant further investigation and may reveal phenomena not captured by conventional monitoring[2]. Cross-validation is particularly valuable for ecosystem extent accounts where benthic habitat classifications must be validated against on-water observations.

¶4 **Third, spatial unit delineation informed by tenure systems.** Indigenous marine tenure systems often reflect ecologically meaningful boundaries developed through generations of resource management practice. In some contexts, customary marine areas provide more ecologically coherent spatial units for ecosystem accounting than administrative boundaries or uniform grid cells. Documentation of customary tenure also supports governance accounts (**TG-3.7 Governance Accounts**), which record the de facto management arrangements that shape ecosystem outcomes.

¶5 The Kunming-Montreal Global Biodiversity Framework (GBF) Target 21 calls for ensuring that "the best available data, information and knowledge are accessible to decision makers, practition-

DRAFT

ers and the public to guide effective and equitable governance, integrated and participatory management of biodiversity"[3]. Traditional knowledge is explicitly recognised as essential to achieving this target. The 2030 Agenda for Sustainable Development similarly recognises the role of Indigenous peoples in sustainable development, including SDG Target 2.3 which calls for doubling "the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers"[4]. For ocean accounting, Target 14.b emphasises providing "access for small-scale artisanal fishers to marine resources and markets," an objective that requires understanding the traditional knowledge and customary practices that underpin small-scale fisheries.

¶6 This Circular builds upon the broader framework for social accounting established in **TG-3.5 Social Accounts**, which addresses wellbeing, equity, and qualitative approaches for documenting human dimensions of ocean-society relationships. The governance dimensions of traditional knowledge systems connect to the institutional documentation frameworks in **TG-3.7 Governance Accounts**. Data collection methods involving community participation are addressed in **TG-4.4 Citizen Science and Community-Based Monitoring**, which provides complementary guidance on working with non-official data sources. The accounts developed using this guidance may inform thematic accounts for coral reefs (**TG-6.1 Coral Reef Ecosystem Accounting**), mangroves (**TG-6.2 Mangrove and Coastal Wetland Accounting**), and seagrass ecosystems (**TG-6.3 Seagrass Ecosystem Accounting**), where traditional knowledge of ecosystem condition and change can complement scientific monitoring.

2. Requirements

¶1 **Essential prerequisites:**

- ¶2 **TG-0.1 General Introduction to Ocean Accounts**: foundational understanding of Ocean Accounts components and environmental-economic accounting frameworks
- ¶3 **TG-3.5 Social Accounts**: broader framework for documenting human dimensions of ocean-society relationships

DRAFT

¶4 ⓘ **Framework Position**

¶5 This Circular addresses how traditional and indigenous knowledge systems can be incorporated into ocean accounts. It sits at the intersection of social accounts (TG-3.5) and governance accounts (TG-3.7), linking community-held knowledge to ecosystem condition assessment and resource management documentation. In the Ocean Accounts Framework (Figure 0.1.2), this Circular primarily relates to edges E6 (social activities influencing social conditions) and E4 (social activities interacting with SNA assets), whilst also informing the environmental stock and flow measurements that depend on observational data from knowledge holders.

¶6 **Scope.** TG-3.6 owns the account treatment of traditional and indigenous knowledge: the co-production principles, the cultural services account, and how knowledge-holder observation enters condition variables. It cross-refers to **TG-3.14** for FPIC and Indigenous Data Sovereignty, **TG-4.4** for community-based monitoring protocols, and **TG-3.1** for the condition account the variables enter.

3. Guidance Material

3.1 Principles for Engagement

¶1 Engagement with Indigenous Peoples and Local Communities (IPLCs) for the purpose of incorporating traditional knowledge into ocean accounts must be grounded in respect for human rights, recognition of Indigenous peoples' self-determination, and adherence to established international principles. The guidance in this section draws on frameworks established by the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), the Convention on Biological Diversity (CBD), the Biodiversity Beyond National Jurisdiction (BBNJ) Agreement, and the Taskforce on Nature-related Financial Disclosures (TNFD). It is supplemented by guidance from the statistical

community, including the United Nations Fundamental Principles of Official Statistics, which affirm that statistical agencies should coordinate with other agencies to achieve consistency and efficiency in the statistical system [5], and the UNSD guidance on strengthening the integration of diverse knowledge systems in official statistics [6].

3.1.1 The significance of traditional knowledge holders

¶1 Traditional knowledge encompasses [7]:

- ¶2 Observational knowledge of species, habitats, and ecological relationships accumulated over generations
- ¶3 Understanding of seasonal patterns, environmental change, and ecosystem dynamics
- ¶4 Practices for sustainable resource use developed through long experience
- ¶5 Governance systems for managing common resources and resolving conflicts
- ¶6 Spiritual and cultural relationships with marine environments
- ¶7 Oral histories documenting environmental change over time

¶8 This knowledge can provide insights not available from short-term scientific monitoring, particularly regarding long-term baselines, rare events, and relationships that require sustained local observation to understand. For ocean accounting, traditional knowledge may inform ecosystem condition assessments (see **TG-3.1 Asset Accounts** Section 3.5.2), ecosystem service identification (see **TG-2.4 Ecosystem Goods and Services**), and understanding of human-ocean relationships that are not captured in standard economic or environmental data.

¶9 Experience from multiple regions demonstrates the practical value of traditional knowledge for marine ecosystem assessment. In the Pacific Islands, customary marine tenure systems have long provided the basis for community-based fisheries management, and traditional ecological knowledge of reef systems has informed both national conservation strategies and regional environmental monitoring [8]. In the Arctic, Indigenous observations of sea ice dynamics, marine mammal behaviour, and shifting species distributions have contributed to understanding environmental change in ways that complement satellite-based monitoring [9]. In Southeast Asia and the Indian Ocean, local fisher knowledge of spawning aggregations, seasonal current patterns, and habitat changes has contributed to marine spatial planning and stock assessments [10]. In each case, traditional knowledge has yielded practical contributions where institutional arrangements supported respectful engagement.

DRAFT

3.1.2 International frameworks for engagement

¶1 Several international instruments establish the framework for engagement with traditional knowledge holders:

¶2 **United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP):** Adopted in 2007, UNDRIP affirms Indigenous peoples' rights to self-determination, to maintain their cultural practices and institutions, and to control their traditional knowledge. Article 31 states that "Indigenous peoples have the right to maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expressions" [11]. Article 26 recognises Indigenous peoples' rights to "the lands, territories and resources which they have traditionally owned, occupied or otherwise used or acquired" [12].

¶3 **Convention on Biological Diversity (CBD):** Article 8(j) requires parties to "respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity" [13]. The Nagoya Protocol on Access and Benefit Sharing establishes specific requirements for access to traditional knowledge associated with genetic resources, including requirements for prior informed consent and fair and equitable benefit sharing [14].

¶4 **Kunming-Montreal Global Biodiversity Framework:** Target 21 specifically calls for ensuring "the full, equitable, inclusive, effective and gender-responsive representation and participation in decision-making, and access to justice and information related to biodiversity by indigenous peoples and local communities, respecting their cultures and their rights over lands, territories, resources, and traditional knowledge"[15]. Target 3 calls for conserving at least 30% of marine and coastal areas "recognizing indigenous and traditional territories, where applicable"[16]. Target 5 calls for ensuring sustainable use of wild species "while respecting and protecting customary sustainable use by indigenous peoples and local communities"[17].

¶5 **ILO Convention 169:** The Indigenous and Tribal Peoples Convention establishes that governments shall "consult the peoples concerned, through appropriate procedures and in particular through their representative institutions, whenever consideration is being given to legislative or administrative measures which may affect them directly"[18].

¶6 **Agreement on Biodiversity Beyond National Jurisdiction (BBNJ Agreement):** The 2023 BBNJ Agreement, adopted under the United Nations Convention on the Law of the Sea, includes provisions specifically relevant to traditional knowledge in areas beyond national jurisdiction. Article 7 provides that the agreement shall be interpreted and applied in a manner that "does not undermine relevant legal instruments and frameworks and relevant global, regional and sectoral bodies" and recognises the "relevant traditional knowledge of Indigenous Peoples and local communities." Part II of the agreement, on marine genetic resources and benefit sharing, establishes that "the collection of marine genetic resources of areas beyond national jurisdiction shall be … with due regard for the interests and rights of … Indigenous Peoples and local communities"[19]. For ocean accounting that extends to high seas areas, these provisions establish the principle that traditional knowledge must be respected even in areas beyond national jurisdiction.

3.1.3 Free, Prior and Informed Consent (FPIC)

¶1 Free, Prior and Informed Consent (FPIC) is the foundational principle for engagement with Indigenous Peoples and Local Communities regarding the use of their traditional knowledge. The TNFD recommends that organisations describe "whether engagement has been based on free, prior and informed consultation and participation and how Free Prior and Informed Consent (FPIC) has been obtained"[20].

DRAFT

¶2 FPIC requires that consent be:

- ¶3 **Free:** Given voluntarily, without coercion, intimidation, or manipulation
- ¶4 **Prior:** Sought sufficiently in advance of any activities, allowing adequate time for consultation and decision-making according to the community's own processes
- ¶5 **Informed:** Based on full disclosure of the purpose, nature, and implications of the proposed engagement, including potential risks and benefits
- ¶6 **Consent:** Documented agreement from the appropriate decision-making bodies according to the community's own governance structures

¶7 For ocean accounting purposes, FPIC should be sought before:

- ¶8 Collecting traditional knowledge for use in accounts
- ¶9 Integrating traditional knowledge with scientific data
- ¶10 Publishing or sharing information derived from traditional knowledge
- ¶11 Making decisions that affect marine areas of cultural significance

¶12 FPIC is an ongoing process rather than a single event at the outset. Communities may withdraw consent, and continued engagement requires continued communication and agreement.

¶13 The process for obtaining FPIC should be documented and included in the metadata for any accounts that incorporate traditional knowledge. This documentation supports the transparency

requirements that apply across all ocean accounting work, as described in **TG-0.7 Quality Assurance Principles**.

3.1.4 Principles for respectful engagement

¶1 Building on the international frameworks, practitioners should adhere to the following principles when engaging with traditional knowledge holders:

¶2 **Recognise community protocols:** Each community has its own protocols for sharing knowledge, including who may speak on behalf of the community, what knowledge may be shared, and under what conditions. Practitioners must invest time in understanding and respecting these protocols before seeking to access traditional knowledge [21].

¶3 **Build long-term relationships:** Meaningful engagement with traditional knowledge holders cannot be achieved through brief consultations or one-time data collection exercises. Practitioners should invest in building sustained relationships based on trust and mutual benefit [22]. This principle of sustained engagement distinguishes traditional knowledge work from standard data collection and has implications for resource allocation and institutional commitment.

¶4 **Respect knowledge ownership:** Traditional knowledge belongs to the communities that hold it, not to researchers or agencies that document it. Even when knowledge is shared, intellectual property rights remain with the knowledge holders [23]. This principle applies regardless of whether knowledge has been formally registered or protected under intellectual property law.

¶5 **Ensure equitable benefit sharing:** Communities should benefit from the use of their knowledge, whether through direct compensation, capacity building, access to results, or other forms of reciprocity [24]. The TNFD recommends describing "how equitable Access and Benefit Sharing has been attained, particularly as it relates to Indigenous Peoples and Local Communities" [25]. Benefit sharing connects to the broader equity considerations addressed in **TG-3.5 Social Accounts**, Section 3.7.

¶6 **Support community priorities:** Engagement should respond to community priorities and concerns, not solely to the data needs of accounting agencies. Where possible, accounting efforts should be designed to serve community information needs as well as national statistical requirements.

DRAFT

3.2 Knowledge Integration Approaches

¶1 The integration of traditional knowledge with scientific data and accounting frameworks presents methodological challenges. Traditional knowledge is typically embedded in integrated worldviews, transmitted orally, and expressed in languages and concepts that may not have direct equivalents in Western scientific frameworks. Integration approaches must respect the integrity of traditional knowledge whilst enabling meaningful contribution to ocean accounts.

¶2 Experience to date suggests that successful integration has been achieved through iterative, relationship-based approaches rather than through standardised data collection protocols. In Fiji, community-based ecosystem assessments have combined traditional indicators of reef health (e.g., presence of particular species, water clarity at specific times of year) with scientific monitoring data to produce fuller condition accounts [26]. In the Torres Strait, collaborative mapping of sea country has combined Indigenous spatial knowledge with satellite-derived habitat maps to improve the accuracy of ecosystem extent accounts [27]. These examples indicate the potential for traditional knowledge to contribute practically to ocean accounting compilations, whilst also demonstrating that integration methods must be adapted to each context. The GOAP Secretariat may wish to facilitate documentation of additional case studies as implementation experience accumulates.

3.2.1 Complementary rather than supplementary

¶1 Traditional knowledge does more than fill gaps in scientific monitoring, and treating it solely as a gap-filling data source understates its contribution. The SEEA Ecosystem Accounting framework recognises that cultural services involve "experiential and intangible services related to the perceived or actual qualities of ecosystems whose existence and functioning contribute to a range of cultural benefits" [28]. Traditional knowledge can inform understanding of these experiential and intangible dimensions that may not be captured by conventional measurement approaches.

¶2 Approaches to integration include:

¶3 **Parallel documentation:** Traditional knowledge and scientific data can be documented in parallel, each using methods appropriate to its nature, with explicit acknowledgement of their different epistemological foundations (the different ways each knowledge system establishes what counts as valid knowledge). This approach respects the integrity of each knowledge system whilst enabling comparison and synthesis.

¶4 **Cross-validation:** Where traditional knowledge and scientific monitoring address similar questions (e.g., species abundance, environmental change), cross-validation can strengthen confidence in findings. Convergent results from different knowledge systems provide stronger evidence than either alone. Divergent results may indicate important phenomena that warrant further investigation [29].

¶5 **Gap identification:** Traditional knowledge can help identify phenomena, relationships, or changes that are not captured by existing monitoring, prompting development of new scientific approaches. Traditional knowledge holders often have long-term observational baselines that extend well beyond the period of scientific record. The SEEA biophysical modelling guidance notes that "using a more recent reference condition (e.g. 1990) is another option" but acknowledges that this "fails to recognize the management of indigenous peoples" [30]. Traditional knowledge can extend baselines to pre-industrial or pre-colonial conditions, though such historical reconstruction requires careful methodological consideration. This is particularly relevant for ecosystem condition accounts, where understanding of historical baselines is essential (see **TG-2.1 Aggregate Biophysical Indicators of Environmental State**).

¶6 **Contextualisation:** Traditional knowledge can provide essential context for interpreting scientific data, including understanding of historical conditions, ecosystem variability, and local factors that affect observations.

¶7 *Table 3.6.1: Traditional knowledge integration principles*

TK Integration Stage	Considerations	Example Applications
Engagement	Free, prior, informed consent	Community consultation protocols
Data collection	Respect for cultural protocols	Seasonal calendars, species knowledge
Validation	TK as complementary evidence	Corroboration of scientific observations
Attribution	Recognition of knowledge holders	Documentation, co-authorship
Benefit sharing	Fair distribution of benefits	Capacity building, data sovereignty

3.2.2 Co-production approaches

¶1 Knowledge co-production involves the collaborative generation of knowledge by scientists and traditional knowledge holders working together as partners. Co-production goes beyond consultation or data extraction to involve Indigenous Peoples and Local Communities in all stages of the research process, from question formulation to interpretation of results [31].

¶2 Table 3.2.2 below summarises four elements of co-production.

Element	Description
Joint problem definition	Research questions and accounting priorities are developed collaboratively, reflecting both scientific interests and community priorities; communities may identify questions that would not occur to outside researchers.
Multiple ways of knowing	Traditional knowledge and scientific knowledge represent different but equally valid ways of understanding the world; neither is simply validated by the other, and both contribute distinct insights.
Shared governance	Decision-making about research design, data management, and dissemination is shared between scientific and community partners, often formalised through research agreements or memoranda of understanding.
Two-way capacity building	Capacity building flows in both directions, with scientists learning from knowledge holders and communities gaining skills in documentation, analysis, and communication.

¶3 For ocean accounting, co-production approaches may be particularly valuable for:

- ¶4 Identifying culturally significant marine areas and their management needs
- ¶5 Understanding ecosystem services that have cultural or spiritual dimensions
- ¶6 Documenting long-term environmental change
- ¶7 Developing locally appropriate indicators of ecosystem condition

¶8 These applications connect to the indicator development processes described in **TG-2.1 Aggregate Biophysical Indicators of Environmental State**.

3.2.3 Documentation methods

¶1 Documentation of traditional knowledge requires methods that are appropriate to its oral and contextual nature. Standard survey instruments developed for scientific data collection may be inappropriate for traditional knowledge, which is often embedded in narratives, ceremonies, and practices rather than expressed as discrete data points.

¶2 Appropriate methods are summarised in Table 3.2.3 below.

DRAFT

Method	Description
Participatory mapping	Collaborative mapping exercises document spatial knowledge about marine areas, including locations of cultural significance, seasonal resource availability, and areas of environmental change. [32]
Oral history documentation	Structured or semi-structured interviews document knowledge holders' observations and experiences, preserving the narrative context that gives meaning to the knowledge.
Participant observation	Extended engagement with communities enables understanding of how traditional knowledge is embedded in practice, revealing knowledge that may not be articulated in response to direct questions.
Community-led documentation	Communities document their own knowledge using methods they control, sharing results with accounting agencies according to agreed protocols.

¶3 All documentation should include clear provenance information, noting who provided the knowledge, under what circumstances, and what conditions govern its use. This approach aligns with the quality assurance principles described in **TG-0.7 Quality Assurance Principles** and the guidance on non-official data sources in **TG-4.4 Citizen Science and Community-Based Monitoring**.

3.2.4 Data sovereignty and ownership

¶1 Data sovereignty refers to the right of communities to control data about themselves, their lands, and their knowledge. For Indigenous Peoples, data sovereignty is an expression of self-determination, enabling communities to make decisions about what data are collected, how they are stored, and who can access them [33].

¶2 The **CARE Principles for Indigenous Data Governance**, developed by the Global Indigenous Data Alliance, provide a framework for operationalising data sovereignty in research and statistical contexts. The four principles are [34]:

- ¶3 **Collective benefit:** Data ecosystems should be designed and function in ways that enable Indigenous Peoples to derive benefit from the data. This includes supporting Indigenous governance, self-determination, and collective wellbeing.
- ¶4 **Authority to control:** Indigenous Peoples' rights and interests in Indigenous data must be recognised, and their authority to control such data must be empowered. This includes recognising Indigenous governance structures and self-determined governance processes.
- ¶5 **Responsibility:** Those working with Indigenous data have a responsibility to share how those data are used to support Indigenous Peoples' self-determination and collective benefit. This requires building respectful relationships and expanding the use of data for Indigenous innovation.
- ¶6 **Ethics:** Indigenous Peoples' rights and wellbeing should be the primary concern at all stages of the data life cycle. This includes minimising harm, maximising benefit, and prioritising justice in relation to Indigenous values and collective interests.

¶7 The CARE Principles complement the FAIR Principles (Findable, Accessible, Interoperable, Reusable) that guide open data practice more broadly. For ocean accounting, both sets of principles should be considered, as open data objectives must be balanced with Indigenous data sovereignty rights.

¶8 Principles for data sovereignty in ocean accounting include:

¶9 **Community ownership:** Data derived from traditional knowledge remain the property of the knowledge-holding community, even when documented by external parties. Agencies should not claim ownership of traditional knowledge they have recorded.

¶10 **Control over access:** Communities should determine who can access data derived from their traditional knowledge and under what conditions. This may include restrictions on commercial use, requirements for attribution, or limitations on sharing with third parties.

¶11 **Capacity to benefit:** Communities should have the capacity to access and use their own data for their own purposes, including through provision of data in accessible formats and support for community data management.

¶12 **Right to refuse:** Communities retain the right to refuse to share knowledge, to withdraw previously shared knowledge from use, or to restrict uses they have not explicitly authorised.

¶13 Practical implementation of data sovereignty may involve:

- ¶14 Research agreements that specify data ownership, access, and use conditions
- ¶15 Community-controlled data repositories where traditional knowledge is stored under community governance
- ¶16 Tiered access systems that distinguish between knowledge that can be shared publicly and knowledge that is restricted
- ¶17 Ongoing community review of how their knowledge is being used in accounts

¶18 These considerations connect to the broader data infrastructure for ocean accounting described in Section 4 of the Technical Guidance.

3.3 Ethical Considerations

¶1 Working with traditional knowledge in ocean accounting raises ethical considerations that extend beyond standard research ethics protocols. These considerations arise from the colonial history of research with Indigenous peoples, the ongoing power imbalances between scientific institutions and local communities, and the distinctive characteristics of traditional knowledge as a form of cultural property.

DRAFT

3.3.1 Historical context and power relations

¶1 Scientific research has historically extracted knowledge from Indigenous peoples and local communities without consent, attribution, or benefit sharing. This extractive approach has contributed to the erosion of traditional knowledge systems and to distrust between communities and research institutions. Practitioners working with traditional knowledge must acknowledge this history and actively work to establish different relationships based on equity and respect [35].

¶2 The TNFD framework recognises that human rights considerations are integral to nature-related assessment, calling for organisations to "describe the organisation's human rights policies and engagement activities, and oversight by the board and management, with respect to Indigenous Peoples, Local Communities, affected and other stakeholders" [36]. Engagement with IPLCs is a human rights issue as well as a methodological one, and this framing should inform all traditional knowledge work in ocean accounting.

¶3 Power imbalances may manifest in:

- ¶4 Whose questions drive research agendas
- ¶5 Whose standards define data quality
- ¶6 Who controls how knowledge is interpreted and presented
- ¶7 Who benefits from the use of traditional knowledge
- ¶8 Whose voices are heard in decision-making

¶9 Addressing these imbalances requires sustained attention and willingness to share power and resources with community partners. This connects to the equity considerations addressed in **TG-3.5 Social Accounts**, Section 3.7, which discusses distributional dimensions of ocean benefits and burdens.

3.3.2 Avoiding misappropriation

¶1 Misappropriation of traditional knowledge occurs when knowledge is used in ways that violate community protocols, infringe intellectual property rights, or harm the interests of knowledge holders. The history of traditional knowledge misappropriation indicates the serious consequences that can result. In the marine context, the documentation and publication of traditional fishing grounds and sacred marine sites without community consent has in some cases led to increased external pressure on these areas, undermining the management systems that traditional knowledge holders sought to protect [37]. In other instances, traditional ecological knowledge about medicinal marine organisms has been used in commercial bioprospecting without acknowledgement or benefit sharing. Safeguards are therefore needed at every stage of engagement.

¶2 Practices that may constitute misappropriation include:

- ¶3 Using traditional knowledge without consent
- ¶4 Failing to acknowledge the source of traditional knowledge
- ¶5 Using knowledge for purposes beyond those consented to
- ¶6 Sharing knowledge with third parties without authorisation
- ¶7 Claiming intellectual property rights over traditional knowledge
- ¶8 Commercialising knowledge without benefit sharing

¶9 To avoid misappropriation, practitioners should:

- ¶10 Obtain FPIC before accessing traditional knowledge
- ¶11 Document the conditions under which knowledge was shared
- ¶12 Restrict use of knowledge to authorised purposes
- ¶13 Maintain attribution in all derived products
- ¶14 Share benefits equitably with knowledge-holding communities
- ¶15 Establish clear agreements regarding intellectual property

DRAFT

3.3.3 Protecting sacred and sensitive knowledge

¶1 Traditional knowledge often includes information that is sacred, secret, or sensitive. Some knowledge may be restricted to particular individuals, clans, or genders. Other knowledge is associated with ceremonies that should not be discussed publicly, or relates to sites and practices that communities wish to protect from outside attention.

¶2 Practitioners must be aware that:

- ¶3 Not all traditional knowledge is intended for sharing
- ¶4 Communities may not disclose the existence of restricted knowledge
- ¶5 Knowledge shared may come with conditions that are not fully articulated
- ¶6 Documentation and publication can harm knowledge that should remain oral

¶7 Approaches for protecting sensitive knowledge include:

- ¶8 Asking explicitly what knowledge may be documented and shared
- ¶9 Respecting indications that some topics are not open for discussion
- ¶10 Establishing review processes where communities approve all uses of their knowledge before publication
- ¶11 Creating restricted-access categories for sensitive information in data management systems
- ¶12 Being willing to exclude certain knowledge from accounts when sharing would violate protocols

¶13 Some aspects of human-ocean relationships may therefore be impossible to document in published accounts. Practitioners should accept these limitations as necessary for ethical practice, and should not treat them as obstacles to complete accounting.

3.3.4 Maintaining cultural integrity

¶1 Integration of traditional knowledge into accounting frameworks risks decontextualisation, whereby discrete data points are extracted from the integrated worldviews that give them meaning. Such decontextualisation can distort the knowledge and obscure the cultural frameworks that are essential to understanding it.

¶2 To maintain cultural integrity:

- ¶3 Present traditional knowledge in ways that preserve its context and meaning
- ¶4 Avoid forcing traditional knowledge into categories derived from Western scientific frameworks when these categories are inappropriate
- ¶5 Include narrative and qualitative elements alongside quantified data (see the qualitative approaches discussed in **TG-3.5 Social Accounts**, Section 3.9)
- ¶6 Acknowledge the limitations of accounting frameworks in representing traditional knowledge
- ¶7 Involve knowledge holders in reviewing how their knowledge is presented

¶8 The SEEA EA emphasises that ecosystem accounting supports ongoing learning and analysis, and that compilation of accounts forms part of an iterative process rather than its conclusion[38]. This iterative framing is particularly relevant for traditional knowledge, where understanding deepens through sustained engagement over time.

3.4 Compilation Procedure for Integrating Traditional Knowledge

¶1 This section provides step-by-step guidance on the compilation process for integrating traditional knowledge into ocean accounts. The procedure follows a phased approach that prioritises relationship-building, ethical review, and quality assurance for mixed-method data. The timelines indicated below are illustrative. Actual engagement timelines will vary substantially depending on

DRAFT

community readiness, agency capacity, and cultural context. In some cases, relationship building alone may require years rather than months.

3.4.1 Phase 1: Pre-engagement assessment (Months 1-3)

¶1 **Step 1.1: Identify relevant communities and knowledge holders**

¶2 Review the ecosystem accounting area to identify Indigenous Peoples and Local Communities with traditional knowledge relevant to the marine areas under consideration. Sources may include:

- ¶3 Existing literature on Indigenous marine tenure systems
- ¶4 Government records of customary fishing rights
- ¶5 NGO documentation of community-based conservation
- ¶6 Previous ethnographic or anthropological research

¶7 **Step 1.2: Assess institutional readiness**

¶8 Evaluate whether the compiling agency has:

- ¶9 Sufficient resources for sustained engagement (minimum 12-18 months)
- ¶10 Personnel with cultural competence or willingness to develop it
- ¶11 Leadership commitment to ethical engagement principles
- ¶12 Budget for fair compensation of knowledge holders
- ¶13 Data management systems capable of implementing data sovereignty protocols

¶14 If institutional readiness is inadequate, defer traditional knowledge engagement until capacity can be strengthened.

¶15 **Step 1.3: Identify potential knowledge contributions**

¶16 Based on preliminary review, identify the specific accounting gaps where traditional knowledge could contribute:

- ¶17 Ecosystem extent: Habitat boundaries, historical extent baselines
- ¶18 Ecosystem condition: Species abundance trends, water quality observations, phenological shifts
- ¶19 Ecosystem services: Cultural services, provisioning services (traditional harvest), regulating services informed by local observation
- ¶20 Spatial units: Customary marine tenure areas as potential ecosystem asset boundaries

¶21 This scoping exercise should be preliminary only. Final determination of what knowledge will be shared must emerge through community engagement.

3.4.2 Phase 2: Relationship building and FPIC (Months 4-9)

¶1 **Step 2.1: Establish initial contact**

¶2 Contact community leadership through appropriate channels (government liaisons, existing relationships, or community-designated contact points). Request permission to discuss the ocean accounts program and potential collaboration.

¶3 **Step 2.2: Community briefing**

¶4 Present information about the ocean accounts program in accessible language and format, explaining:

- ¶5 What ocean accounts are and how they will be used
- ¶6 What types of information the agency hopes communities might share
- ¶7 How traditional knowledge would be documented and stored
- ¶8 What benefits might accrue to the community from participation
- ¶9 What risks or sensitivities might arise

DRAFT

¶10 Provide materials in local languages where possible. Allow adequate time for community deliberation according to their own decision-making processes.

¶11 **Step 2.3: Negotiate terms of engagement**

¶12 If the community expresses interest in participating, negotiate terms covering:

- ¶13 What knowledge may be shared and what restrictions apply
- ¶14 How knowledge holders will be compensated for their time
- ¶15 How the community will be acknowledged in publications
- ¶16 What review processes will be established for community approval of outputs
- ¶17 How data sovereignty will be implemented
- ¶18 What benefit-sharing arrangements will apply
- ¶19 Under what circumstances the community may withdraw consent

¶20 **Step 2.4: Formalise agreement**

¶21 Document terms in a memorandum of understanding or research agreement signed by community representatives and agency officials. The agreement should specify:

- ¶22 Scope of knowledge to be documented
- ¶23 Data ownership and access conditions
- ¶24 Attribution and acknowledgement requirements
- ¶25 Compensation arrangements
- ¶26 Review and approval procedures
- ¶27 Dispute resolution mechanisms
- ¶28 Duration of agreement and conditions for renewal or termination

3.4.3 Phase 3: Knowledge documentation (Months 10-15)

¶1 **Step 3.1: Select documentation methods**

¶2 In consultation with the community, select appropriate documentation methods from those described in Section 3.2.3. Methods should align with community preferences and the nature of the knowledge being documented.

DRAFT

¶3 **Step 3.2: Conduct knowledge documentation**

¶4 Implement the agreed documentation methods, adhering to:

- ¶5 Community protocols for knowledge sharing
- ¶6 Compensation arrangements for knowledge holders' time
- ¶7 Cultural protocols regarding who may speak on what topics
- ¶8 Restrictions on recording or documentation in certain contexts

¶9 Documentation should capture not only the knowledge content but also provenance metadata including:

- ¶10 Identity of knowledge holders (with consent for attribution)
- ¶11 Date and location of documentation
- ¶12 Context in which knowledge was shared
- ¶13 Any restrictions or conditions on use
- ¶14 Relationships between knowledge holders and the marine areas being discussed

¶15 **Step 3.3: Community review**

¶16 Provide documented knowledge back to the community for review. Correct any errors, remove any information the community determines should not have been included, and clarify any ambiguities. This review process is distinct from the final output review, and it ensures the documentation accurately reflects what knowledge holders intended to communicate.

3.4.4 Phase 4: Quality assurance for mixed-method data (Months 16-18)

¶1 **Step 4.1: Assess fit-for-purpose for accounting**

¶2 Evaluate documented traditional knowledge against accounting requirements, considering:

- ¶3 **Spatial coverage:** Does the knowledge pertain to specific ecosystem assets or spatial units in the accounting area?
- ¶4 **Temporal relevance:** Does the knowledge provide baselines, trends, or current observations aligned with accounting periods?
- ¶5 **Measurement units:** Can the knowledge be expressed in or translated to units compatible with accounting tables (hectares, species counts, qualitative condition classes, etc.)?
- ¶6 **Uncertainty:** What is the confidence level in the knowledge? How might uncertainty be characterised and communicated?

¶7 **Step 4.2: Identify cross-validation opportunities**

¶8 Where traditional knowledge and scientific data address similar questions, plan for cross-validation:

- ¶9 Convergent findings strengthen confidence in both knowledge systems
- ¶10 Divergent findings signal areas requiring further investigation
- ¶11 Document both convergence and divergence transparently

¶12 **Step 4.3: Develop integration approach**

¶13 Based on the assessment, select the appropriate integration approach from Section 3.2.1:

- ¶14 **Parallel documentation:** Traditional knowledge recorded in supplementary tables alongside scientific data
- ¶15 **Cross-validation:** Traditional knowledge used to validate scientific classifications or model outputs
- ¶16 **Gap-filling:** Traditional knowledge fills spatial or temporal gaps in scientific monitoring
- ¶17 **Contextualisation:** Traditional knowledge provides interpretive context for scientific data

¶18 Most compilations will use a combination of these approaches for different knowledge types.

¶19 **Step 4.4: Quality documentation**

¶20 Document quality dimensions following **TG-0.7 Quality Assurance Principles**:

- ¶21 **Accuracy:** Characterise uncertainty in traditional knowledge observations
- ¶22 **Coherence:** Assess consistency with other data sources where overlap exists
- ¶23 **Relevance:** Confirm alignment with policy and decision-maker needs
- ¶24 **Timeliness:** Note the time period to which knowledge pertains
- ¶25 **Accessibility:** Describe access conditions including data sovereignty restrictions
- ¶26 **Metadata:** Provide complete provenance documentation

3.4.5 Phase 5: Integration into accounts and community review (Months 19-21)

¶1 **Step 5.1: Integrate into accounting tables**

¶2 Incorporate traditional knowledge into the relevant account types:

- ¶3 **Extent accounts:** Use traditional knowledge for historical baseline estimates, habitat boundary validation, or identification of previously unmapped ecosystem types
- ¶4 **Condition accounts:** Incorporate traditional indicators alongside scientific metrics, noting the knowledge source for each indicator
- ¶5 **Services accounts:** Document cultural services, validate provisioning service estimates, or contextualise regulating service assessments

DRAFT

- ¶6 **Monetary accounts:** Where appropriate, traditional knowledge may inform valuation of cultural services or historical resource rent calculations

¶7 **Step 5.2: Draft supplementary documentation**

¶8 Prepare supplementary text explaining:

- ¶9 How traditional knowledge was obtained (summarising the FPIC process without disclosing sensitive details)
- ¶10 What knowledge was incorporated and from which communities
- ¶11 What restrictions or conditions apply to use of the knowledge
- ¶12 How quality assurance was conducted for traditional knowledge contributions
- ¶13 What limitations or uncertainties users should be aware of

¶14 **Step 5.3: Community review of outputs**

¶15 Provide draft accounts and supplementary documentation to the community for review. The community should assess:

- ¶16 Whether their knowledge is accurately represented
- ¶17 Whether any sensitive information has inadvertently been included
- ¶18 Whether attribution and acknowledgement are appropriate
- ¶19 Whether the integration respects the integrity of their knowledge

¶20 Revise accounts based on community feedback. If the community determines that publication would violate protocols, respect that determination even if it means removing substantial content from accounts.

¶21 **Step 5.4: Final approval**

¶22 Obtain written community approval before publication. Archive the approval documentation as part of the accounts metadata.

3.4.6 Ongoing engagement and benefit sharing

¶1 Traditional knowledge integration is not complete upon publication of accounts. Ongoing responsibilities include:

- ¶2 Provide communities with copies of published accounts in accessible formats
- ¶3 Share information about how accounts are being used in policy or decision-making
- ¶4 Fulfil any benefit-sharing commitments (capacity building, data access, etc.)
- ¶5 Maintain communication to support continued consent for use of knowledge
- ¶6 Consult the community before any new uses of their knowledge
- ¶7 Support community-led monitoring or data management initiatives where feasible

3.5 Cultural Services and Traditional Knowledge

¶1 Traditional knowledge relates closely to the cultural ecosystem services recognised in the SEEA Ecosystem Accounting framework. Cultural services include "recreation-related services, visual amenity services, education, science and research services, spiritual, artistic and symbolic services at the most detailed level"[39]. For many Indigenous Peoples and coastal communities, marine ecosystems provide cultural services that are central to identity, spiritual practice, and intergenerational knowledge transmission.

3.5.1 Cultural services in ocean contexts

¶1 Marine cultural services that may be informed by traditional knowledge include:

¶2 **Spiritual and ceremonial connections:** Marine areas may be sites of spiritual significance, associated with ancestral beings, creation stories, or ongoing ceremonial practice. Traditional knowl-

DRAFT

edge holders can identify these sites and articulate their significance, though this knowledge may be sensitive and subject to restrictions on sharing. The SEEA EA recognises that "there may be traditional harvests undertaken by indigenous groups" and that "if the harvest is retained for subsequent consumption, then the quantity of the associated biomass should be included as part of biomass provisioning services. At the same time, there would be a connection to the measurement of cultural services. In these instances, flows of cultural services should be recorded in addition to biomass provisioning services" [40].

¶3 **Customary resource use:** The gathering of marine resources for customary purposes contributes to cultural continuity and intergenerational knowledge transmission. Understanding these practices requires engagement with traditional knowledge holders who can explain the cultural dimensions that distinguish customary use from commercial extraction. This connects to the discussion of ocean sector employment in **TG-3.5 Social Accounts**, Section 3.6.2.

¶4 **Place-based knowledge and identity:** For coastal communities, marine environments are often central to collective identity. Traditional place names, navigation knowledge, and environmental knowledge contribute to sense of place and cultural identity that cannot be captured in conventional ecosystem service metrics.

¶5 **Educational and intergenerational transmission:** Marine environments serve as sites for education and knowledge transmission, where younger generations learn from elders through observation and practice. This educational service depends on the continued health of marine ecosystems and continuity of cultural practices.

¶6 For guidance on the broader framework for cultural ecosystem services, see **TG-2.4 Ecosystem Goods and Services**. The full mapping of cultural service categories to traditional knowledge contributions is provided in Table 3.6.3 below.

3.5.2 Cultural ecosystem services framing for traditional knowledge contributions

¶1 The cultural-service framing established in the international classifications (the Millennium Ecosystem Assessment (MEA), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the Common International Classification of Ecosystem Services (CICES) v5.1, and SEEA Ecosystem Accounting Chapter 6) provides a structured entry point for incorporating traditional knowledge into ocean accounts, whilst leaving the integrity of the knowledge itself unchanged. The MEA defines cultural services as the non-material benefits people obtain from ecosystems [41]. IPBES recognises analogous non-material contributions, including supporting identities, learning and inspiration, and physical and psychological experiences [42]. CICES v5.1 organises cultural services into direct in-situ interactions and indirect interactions [43]. SEEA EA defines cultural services as "experiential and intangible services related to the perceived or actual qualities of ecosystems whose existence and functioning contribute to a range of cultural benefits" [44] and notes (para. 6.97) the joint recording of customary harvest as both biomass provisioning and cultural service flows [45].

¶2 Traditional knowledge holders are often the principal source of information on five categories of cultural service that are otherwise difficult to observe. Each of these connects a biophysical condition signal (documented in **TG-2.1 Aggregate Biophysical Indicators of Environmental State** and **TG-3.1 Asset Accounts** Section 3.5.2) to a social or cultural dimension recorded under **TG-3.5 Social Accounts**, Section 3.9. Practitioners may consider this framing as a candidate organising structure. Specific indicator sets, units, and beneficiary classes should be co-designed with knowledge holders and need not follow the categories below rigidly.

¶3 **Recreation and customary use as a cultural service.** Recreation in the CICES and SEEA EA senses includes structured market-based activities (tourism, recreational fishing) and also non-market customary practices such as gleaning of invertebrates, seasonal harvest of finfish, and gathering of marine plants. Where customary practices have strong cultural and social dimensions (intergenerational transmission, gendered roles, ceremonial timing), SEEA EA permits joint recording

DRAFT

as a cultural service alongside biomass provisioning [45]. Traditional knowledge holders can articulate which specific harvest practices carry these cultural dimensions, which species or sites are involved, and which condition signals (target species abundance, habitat extent, water clarity) most directly affect the continuity of the practice. Worked numeric examples illustrating coral reef recreation, mangrove ecotourism, and invertebrate gleaning are presented in the case studies under **TG-5.1 Australia** through **TG-5.10 Vietnam**. This Circular is method-agnostic on valuation and does not endorse specific parameter values.

¶4 **Sense of place and named features.** Sense of place is recognised by IPBES under "supporting identities" [42] and by CICES under spiritual and symbolic interactions [43]. Traditional knowledge often comprises detailed place-based vocabularies (named reefs, passages, anchorages, and seasonal grounds) that may have no equivalent in scientific gazetteers. Practitioners may consider recording the existence and number of such named features (with community consent), the proportion of community members reporting strong attachment to them, and any documented changes in their physical state. The condition–wellbeing linkage is direct but often non-linear: a culturally significant feature may retain its identity value across a wide range of biophysical conditions yet become a focus of community concern when condition crosses a locally recognised threshold.

¶5 **Customary stewardship and customary tenure.** Customary tenure systems (locally managed marine areas, taboo zones, seasonal closures) are recognised in CBD GBF Targets 3 and 5 and in the BBNJ Agreement. Where present, these systems are themselves cultural and institutional outcomes of long-term human-ocean relationships. Traditional knowledge holders may identify the spatial extent, governance arrangements, and current status of customary tenure, information that contributes to the cultural-service account of the present Circular and to the governance account under **TG-3.7 Governance Accounts**. Practitioners may consider recording the presence, extent, and observed enforcement of customary tenure as a candidate indicator, with the spatial details treated under data sovereignty protocols where required.

¶6 **Intergenerational transmission of marine knowledge.** SEEA EA recognises education, science, and research as a cultural service category [44]. For many coastal communities, the marine environment is the principal site of intergenerational learning, and the continuity of that learning is itself an indicator of cultural-service supply. Traditional knowledge holders are the only authoritative source on whether transmission is occurring, declining, or interrupted. Practitioners may consider recording, in close consultation with communities, whether elders report that customary practices are being taught to younger generations, and whether this transmission is constrained by condition decline, access restrictions, or social change.

¶7 **Spiritual and ceremonial connections and non-use values.** Some cultural services arise without direct economic interaction: the value attached to the existence of a sacred site, an ancestral being, or a species of cultural significance. The MEA and IPBES both recognise these dimensions. SEEA EA is cautious about including pure existence values in monetary ecosystem service accounts but supports their recording in supplementary or qualitative form [44]. For traditional knowledge contributions, the protocols in Section 3.3.3 of this Circular apply: some spiritual and ceremonial dimensions may not be appropriate for public documentation and may be recorded only under restricted-access arrangements or excluded by community decision.

¶8 *Table 3.6.3: Cultural ecosystem service categories and candidate traditional knowledge contributions*

DRAFT

Cultural service category (per SEEA EA / CICES v5.1)	Candidate TK contribution	Linked condition signal (TG-2.1 / TG-2.3)	Linked social-account dimension (TG-3.5 Section 3.9)
Physical and experiential interactions (recreation, customary harvest)	Identification of culturally significant harvest practices, species, sites, and seasonal calendars	Target species abundance; habitat extent; water clarity	Recreation and nature-based tourism; customary and subsistence use
Spiritual, symbolic and other interactions	Identification of sacred sites, ancestral narratives, ceremonial use (subject to community protocols)	Condition of named features; integrity of cultural seascapes	Sense of place, cultural identity, spiritual values
Education and intergenerational transmission	Assessment of transmission status; identification of teaching sites and practices	Continued ecosystem functioning at teaching sites	Education and intergenerational transmission
Heritage and identity	Traditional place names; navigation knowledge; named feature inventories	Persistence of recognisable seascape features	Sense of place; non-use values

¶9 The cultural-service framing above is offered as a candidate scaffolding only. Practitioners may consider it where it supports community priorities and aligns with the protocols agreed under Section 3.4. Where the cultural-service vocabulary is unfamiliar or culturally inappropriate, the substantive content (named places, harvest practices, transmission status) may be recorded in narrative form following the qualitative approaches in **TG-3.5 Social Accounts**, Section 3.9. In all cases, the integrity of the underlying traditional knowledge takes precedence over fit with classification schemes; accounting frameworks should adapt to the knowledge, not the reverse.

3.5.3 Connections to governance accounts

¶1 Traditional knowledge systems often include customary governance institutions that regulate access to marine resources and mediate conflicts. These customary systems may operate alongside or in tension with formal legal frameworks. Governance accounts should document customary governance arrangements where they influence marine management outcomes.

¶2 The TNFD defines Local Communities partly in terms of their governance characteristics, noting that they may have "a set of social rules (e.g. that regulate land conflicts/sharing of benefits) and organisational-specific community/traditional/customary laws and institutions"[46]. For ocean accounting, documentation of these customary institutions can inform understanding of actual governance arrangements in marine areas.

¶3 **TG-3.7 Governance Accounts** provides guidance on documenting customary governance alongside formal legal frameworks, including in Section 3.2.2 on customary law and Section 3.1.2 on multi-level governance structures that incorporate co-management arrangements.

4. Worked Example

¶1 This section presents a hypothetical worked example illustrating how traditional knowledge might be incorporated into ocean accounts for a Pacific Island context. The example is entirely fictional and is designed to demonstrate the accounting structures and engagement processes described in this Circular. It is not based on any specific community or knowledge system, and should not be taken as representative of any particular Indigenous People or Local Community. In practice, every engagement with traditional knowledge holders must be tailored to the specific cultural context and conducted in accordance with the principles set out in Section 3.1.

DRAFT

4.1 Scenario: Mangrove cultural value assessment in a hypothetical Pacific Island community

¶1 **Setting.** A national statistical office (NSO) in a Pacific Island State is compiling ecosystem accounts for a coastal lagoon system that includes 850 hectares of mangrove forest. Scientific monitoring data (satellite imagery, field surveys) provide information on mangrove extent and biophysical condition. However, the NSO recognises that the mangroves also provide cultural services to the adjacent community of approximately 2,500 people who have customary tenure over the lagoon, and that these cultural dimensions are not captured by existing scientific data.

¶2 **Objective.** To incorporate traditional knowledge contributions into the cultural services component of the ecosystem accounts for the lagoon system, following the principles and processes described in this Circular.

4.2 FPIC process steps applied to the assessment

¶1 The NSO follows the FPIC process described in Section 3.1.3. The steps below illustrate how FPIC principles translate into practice for this hypothetical case:

FPIC Step	Action Taken	Timeline
1. Free — Initial contact (see §3.1.3)	NSO contacts community leadership through existing government liaison channels; requests a meeting to discuss the project	Month 1
2. Prior — Community briefing (see §3.1.3)	NSO staff visit the community, explain the ocean accounts programme, and describe what information they hope the community might share; materials provided in local language	Month 2
3. Prior — Community deliberation (see §3.1.3)	Community leadership consults with elders, clan heads, and knowledge holders using their own decision-making processes; NSO is not present during deliberation	Months 3-5
4. Informed — Conditions negotiated (see §3.1.3)	Community agrees to participate, subject to conditions: (a) sacred site locations will not be published or georeferenced in public accounts; (b) all outputs will be reviewed by community before release; (c) community members who contribute knowledge will be compensated for their time; (d) the community will be acknowledged as knowledge holders in all publications	Month 6
5. Consent — Agreement documented (see §3.1.3)	A memorandum of understanding is signed between the NSO and the community governance body, recording the terms of engagement and data use conditions	Month 6
6. Ongoing consent (see §3.1.3)	At each subsequent stage, the NSO confirms that the community is comfortable proceeding; the community retains the right to withdraw	Ongoing

4.3 Cultural services account template

¶1 Based on the engagement process, the NSO compiles a supplementary cultural services account for the mangrove lagoon system. The account uses a parallel documentation approach (Section 3.2.1), recording scientific and traditional knowledge contributions side by side:

¶2 *Table 4.1: Cultural services account — mangrove lagoon system (hypothetical)*

DRAFT

Cultural service category (per SEEA EA)	Scientific data contribution	Traditional knowledge contribution	Recording in accounts
Spiritual, artistic, and symbolic	Not available from scientific monitoring	Elders identify three areas within the mangrove system associated with ancestral narratives and ongoing ceremonial practice; one area is designated as restricted (not to be published)	Supplementary note: "Three culturally significant areas identified by community knowledge holders; spatial details held under community data sovereignty protocols per MOU dated [date]"
Recreation-related (customary use)	Satellite data show access trails to mangrove areas	Community members describe traditional gleaning practices: collection of shellfish, crabs, and medicinal plants from specific mangrove zones, following seasonal calendars	Supplementary table: seasonal calendar of customary harvest activities (4 species groups, 12-month cycle), compiled from community workshops
Education, science, and research	Monitoring data cover 15 years (2010-2025)	Elders provide oral history observations spanning approximately 60 years, noting changes in species composition, water clarity, and mangrove extent since the 1960s	Supplementary note: "Community observations extend the baseline for condition assessment by approximately 45 years; key reported changes include [summary of reported changes, reviewed and approved by community]"
Heritage and cultural identity	Not captured in biophysical monitoring	Community identifies 12 traditional place names within the lagoon system, each associated with specific ecological features and use practices; 7 medicinal species identified by traditional healers	Supplementary table: traditional place names and associated ecological features (12 entries); medicinal species inventory (7 entries, common names and uses, with community consent for publication)

DRAFT

4.4 Traditional knowledge inputs to condition accounts

¶1 In addition to the cultural services account, traditional knowledge may contribute to ecosystem condition assessment. The following illustrative entries show how TK observations might appear alongside scientific indicators in a condition account:

¶2 *Table 4.2: Condition variable inputs from traditional knowledge (illustrative)*

Condition variable (per SEEA EA)	Scientific indicator	TK-informed indicator	Integration notes
Species composition	Species richness from field survey (35 fish species, 2024)	Elders report that 5 fish species commonly present 40 years ago are now rarely seen; 2 new species have appeared in last decade	Cross-validation: 3 of the 5 reported absent species are confirmed absent in 2024 survey; the 2 new species are confirmed present; findings converge
Ecosystem extent	Satellite-derived mangrove extent: 850 ha (2024)	Community reports that mangroves extended approximately 200 m further seaward in the 1970s; a specific area of 40 ha was lost to coastal development in the 1990s	Gap identification: satellite record begins 2000; TK extends baseline to 1960s; reported loss of 40 ha is consistent with land use records

Condition variable (per SEEA EA)	Scientific indicator	TK-informed indicator	Integration notes
Water quality	Turbidity measurements from 3 monitoring stations (monthly since 2018)	Fishers report that water clarity has declined noticeably since a road construction project upstream in 2015; traditionally, the bottom was visible at 3 m depth in the lagoon centre	Contextualisation: TK provides pre-monitoring baseline and identifies likely cause of observed turbidity increase

4.5 Benefit-sharing and capacity building outcomes

¶1 As part of the agreed benefit-sharing arrangements, the NSO provides:

1. ¶2 **Financial compensation:** Knowledge holders who participated in documentation workshops receive hourly compensation at local professional rates (40 person-hours total)
2. ¶3 **Capacity building:** The NSO conducts a 2-day training workshop for 15 community members on basic ecosystem accounting concepts and how community knowledge contributes to national accounts
3. ¶4 **Data access:** The community receives a complete copy of the lagoon ecosystem accounts in print and digital formats, along with spatial data layers showing mangrove extent and condition
4. ¶5 **Ongoing engagement:** The NSO establishes an annual reporting schedule where accounts updates are shared with the community, and the community provides feedback on whether their knowledge continues to be appropriately represented

4.6 Key observations from the worked example

¶1 This hypothetical example illustrates several important points about traditional knowledge integration:

1. ¶2
   FPIC is a process, not an event. The engagement timeline spans at least six months before substantive knowledge exchange begins, and consent is maintained on an ongoing basis.
2. ¶3
   Not all knowledge appears in published accounts. The sacred site locations are recorded under community data sovereignty protocols and do not appear in public accounts. This is consistent with the principle in Section 3.3.3 that some aspects of human-ocean relationships cannot be documented in published accounts.
3. ¶4
   TK contributions appear as supplementary notes and tables, not as modifications to core SEEA accounts. The core extent and condition accounts retain their scientific basis, whilst TK contributions are recorded in supplementary tables that provide additional context, extended baselines, and culturally significant information.
4. ¶5
   Cross-validation strengthens both knowledge systems. Where TK observations and scientific data converge (e.g., on species disappearances), confidence in both is increased. Where they diverge, this signals areas for further investigation.
5. ¶6
   The cultural services account captures dimensions that scientific monitoring cannot. Spiritual significance, traditional place names, and customary use practices are inherently qualitative and community-specific; they can only be documented through respectful engagement with knowledge holders.
6. ¶7

DRAFT

Benefit-sharing is concrete and ongoing. The example includes specific financial, capacity-building, and data-access benefits that continue beyond the initial engagement period.

¶8 Compilers should note that this example represents a favourable scenario in terms of community willingness to engage and clarity of governance structures. In practice, engagement may encounter challenges not illustrated here, including community disagreement about knowledge sharing, capacity constraints within the NSO, language barriers, and political sensitivities. The principles in Section 3.1 provide guidance for working through these challenges.

5. Compilation Considerations

5.1 Capacity and resources

¶1 Working with traditional knowledge requires substantial investment in relationship building, culturally appropriate methods, and sustained engagement. Agencies considering incorporation of traditional knowledge into ocean accounts should secure adequate:

- ¶2 Time for relationship building before data collection begins (minimum 6-12 months)
- ¶3 Personnel with cultural competence and community engagement skills
- ¶4 Resources for fair compensation of knowledge holders
- ¶5 Capacity for ongoing community engagement, not one-time data extraction
- ¶6 Commitment from leadership to ethical engagement principles
- ¶7 Budget for translation and interpretation services where needed
- ¶8 Legal review capacity for research agreements and data sovereignty arrangements

¶9 Resource planning for traditional knowledge engagement should recognise that timelines and costs differ substantially from conventional data collection. Agencies should anticipate that the relationship-building phase alone may require six to twelve months before substantive knowledge exchange can begin. Budget allocations should include provision for community liaison officers, travel to community locations, translation and interpretation services, compensation for knowledge holders' time, and community review of outputs. Many agencies have underestimated these requirements, leading to inadequate engagement that fails to meet ethical standards or to produce reliable contributions to accounts. Where resources are insufficient for ethical engagement, it may be more appropriate to defer traditional knowledge integration until adequate support can be secured, rather than proceeding with superficial consultation that risks eroding community trust.

5.2 Limitations and uncertainties

¶1 The incorporation of traditional knowledge into ocean accounts involves uncertainties:

- ¶2 Traditional knowledge may address different questions and use different concepts than those in accounting frameworks
- ¶3 Knowledge varies among individuals and communities, and aggregation may obscure important local variation
- ¶4 Not all traditional knowledge can or should be documented
- ¶5 Integration with scientific data involves translation between incommensurable knowledge systems (knowledge systems based on fundamentally different assumptions and methods)
- ¶6 Methods for validation and quality assurance are not well established

¶7 Accounts incorporating traditional knowledge should clearly document these limitations and avoid overstating the precision or completeness of traditional knowledge contributions.

¶8 The quality assurance framework in **TG-0.7 Quality Assurance Principles** provides general guidance on uncertainty characterisation. For traditional knowledge, uncertainty characterisation

should address the cultural and contextual dimensions noted above, not only measurement uncertainty in the statistical sense.

5.3 Reporting and attribution

¶1 When traditional knowledge contributes to ocean accounts, the contribution should be clearly acknowledged:

- ¶2 Credit knowledge-holding communities in account documentation
- ¶3 Distinguish traditional knowledge contributions from scientific data sources
- ¶4 Note any restrictions on use or sharing that apply to traditional knowledge components
- ¶5 Provide copies of relevant accounts to contributing communities
- ¶6 Recognise individual knowledge holders where they have consented to attribution

¶7 These practices align with the metadata and provenance documentation requirements discussed in **TG-4.4 Citizen Science and Community-Based Monitoring**, Section 3.3.

5.4 Connections with related circulars

¶1 This Circular connects to several other components of the Technical Guidance:

- ¶2 **TG-3.5 Social Accounts:** Provides the broader framework for documenting human dimensions of ocean-society relationships, including wellbeing indicators and qualitative approaches
- ¶3 **TG-3.7 Governance Accounts:** Addresses documentation of customary governance systems alongside formal legal frameworks
- ¶4 **TG-4.4 Citizen Science and Community-Based Monitoring:** Provides complementary guidance on community-based data collection and integration with official statistics
- ¶5 **TG-2.4 Ecosystem Goods and Services:** Addresses cultural ecosystem services that may be informed by traditional knowledge
- ¶6 **TG-0.7 Quality Assurance Principles:** Provides general quality framework applicable to all data sources
- ¶7 **TG-6.1 Coral Reef Ecosystem Accounting**, **TG-6.2 Mangrove and Coastal Wetland Accounting**, **TG-6.3 Seagrass Ecosystem Accounting:** Thematic accounts where traditional knowledge of ecosystem condition can complement scientific monitoring

Implementation Considerations

¶1 For minimum institutional capacity, data infrastructure, and human skills requirements for compiling these accounts, see TG-0.8 Implementation Readiness Assessment. For guidance on adapting these methods to sub-national scales, see TG-3.11 Sub-National Ocean Accounts.

6. References and Further Reading

- ¶1 United Nations Declaration on the Rights of Indigenous Peoples (2007)
- ¶2 Convention on Biological Diversity, Article 8(j) and Nagoya Protocol
- ¶3 Kunming-Montreal Global Biodiversity Framework (2022), Targets 3, 5, 21
- ¶4 Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ Agreement, 2023)
- ¶5 TNFD Recommendations and Guidance on Engagement with Indigenous Peoples, Local Communities and Affected Stakeholders (2023)
- ¶6 SEEA Ecosystem Accounting, Chapter 6 (Ecosystem Services)
- ¶7 ILO Convention 169 on Indigenous and Tribal Peoples
- ¶8 Global Indigenous Data Alliance, CARE Principles for Indigenous Data Governance (2019)

DRAFT

- ¶9 United Nations Fundamental Principles of Official Statistics (2014)
- ¶10 SEEA Guidelines on Biophysical Modelling for Ecosystem Accounting, Section 5.7 (Reference Conditions)
- ¶11 Millennium Ecosystem Assessment (2005), *Ecosystems and Human Well-being: Synthesis*
- ¶12 IPBES (2019), *Global Assessment Report on Biodiversity and Ecosystem Services*
- ¶13 Common International Classification of Ecosystem Services (CICES) v5.1 (Haines-Young and Potschin, 2018)

¶14 **Authors:** [To be confirmed] **Reviewers:** [To be confirmed] **Last Updated:** February 2026

FOOTNOTES

1. ¶1 Huntington, H.P. et al. (2004). Matching traditional and scientific observations to detect environmental change: a discussion on Arctic terrestrial ecosystems. Ambio 33(7): 18-23.
2. ¶2 Tengoe, M. et al. (2017). Weaving knowledge systems in IPBES, CBD and beyond. Current Opinion in Environmental Sustainability 26-27: 17-25.
3. ¶3 Convention on Biological Diversity, Kunming-Montreal Global Biodiversity Framework (2022), Target 21.
4. ¶4 United Nations, Transforming our world: the 2030 Agenda for Sustainable Development, SDG Target 2.3.
5. ¶5 United Nations Fundamental Principles of Official Statistics (2014), Principle 8: Coordination among statistical agencies.
6. ¶6 See also UNSD and UNESCO Institute for Statistics discussions on integrating Indigenous knowledge into statistical frameworks, and the Pacific Community (SPC) regional guidance on cultural statistics.
7. ¶7 This characterization draws on Convention on Biological Diversity (2018), Glossary of Relevant Terms, definition of "Traditional knowledge."
8. ¶8 Vierros, M. et al. (2010). Traditional Marine Management Areas of the Pacific in the Context of National and International Law and Policy. United Nations University – Institute of Advanced Studies.
9. ¶9 Huntington, H.P. et al. (2004). Matching traditional and scientific observations to detect environmental change: a discussion on Arctic terrestrial ecosystems. Ambio 33(7): 18-23. Whilst focused on terrestrial ecosystems, the methodological framework for integrating traditional and scientific observations applies equally to marine contexts.
0. ¶10 Johannes, R.E. (1998). The case for data-less marine resource management: examples from tropical nearshore finfisheries. Trends in Ecology and Evolution 13(6): 243-246.
1. ¶11 United Nations Declaration on the Rights of Indigenous Peoples (2007), Article 31.
2. ¶12 United Nations Declaration on the Rights of Indigenous Peoples (2007), Article 26.
3. ¶13 Convention on Biological Diversity (1992), Article 8(j).
4. ¶14 Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity (2010).
5. ¶15 Convention on Biological Diversity, Kunming-Montreal Global Biodiversity Framework (2022), Target 21.
6. ¶16 Convention on Biological Diversity, Kunming-Montreal Global Biodiversity Framework (2022), Target 3.
7. ¶17 Convention on Biological Diversity, Kunming-Montreal Global Biodiversity Framework (2022), Target 5.
8. ¶18 International Labour Organization, Indigenous and Tribal Peoples Convention, 1989 (No. 169), Article 6.
9. ¶19 Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction (2023), Articles 7 and 13.
0. ¶20 TNFD Recommendations (2023), Governance Disclosure C.
1. ¶21 TNFD Guidance on engagement of Indigenous Peoples, Local Communities and affected stakeholders.
2. ¶22 Johnson, N. et al. (2016). The contributions of community-based monitoring and traditional knowledge to Arctic observing networks. Arctic 69(Suppl. 1): 28-40.
3. ¶23 United Nations Declaration on the Rights of Indigenous Peoples (2007), Article 31.
4. ¶24 Nagoya Protocol (2010), Articles 5-7.
5. ¶25 TNFD Recommendations (2023), Governance Disclosure C.
6. ¶26 Jupiter, S.D. et al. (2014). Locally-managed marine areas: multiple objectives and diverse strategies. Pacific Conservation Biology 20(2): 165-179.
7. ¶27 Weiss, K. et al. (2012). Knowledge exchange and policy reform: linking marine science with management practice in Torres Strait. International Journal of Science in Society 3(2): 39-56.
8. ¶28 SEEA Ecosystem Accounting (2021), para. 6.51.
9. ¶29 Tengoe, M. et al. (2017). Weaving knowledge systems in IPBES, CBD and beyond. Current Opinion in Environmental Sustainability 26-27: 17-25.
0. ¶30 SEEA Guidelines on Biophysical Modelling for Ecosystem Accounting, paras. 183-184.
1. ¶31 Hill, R. et al. (2020). Working with Indigenous, local and scientific knowledge in assessments of nature and nature's linkages with people. Current Opinion in Environmental Sustainability 43: 8-20.
2. ¶32 For related guidance on spatial representation in ocean accounts, see TG-0.3 Spatial and Temporal Frameworks.
3. ¶33 Global Indigenous Data Alliance, CARE Principles for Indigenous Data Governance (2019).

DRAFT

4. ¶34 Carroll, S.R. et al. (2020). The CARE Principles for Indigenous Data Governance. Data Science Journal 19(1): 43.
5. ¶35 Smith, L.T. (2021). Decolonizing Methodologies: Research and Indigenous Peoples (3rd ed.). Zed Books.
6. ¶36 TNFD Recommendations (2023), Governance C.
7. ¶37 Foale, S. (2006). The intersection of scientific and indigenous ecological knowledge in coastal Melanesia: implications for contemporary marine resource management. International Social Science Journal 58(187): 129-137.
8. ¶38 SEEA Ecosystem Accounting (2021), Chapter 1. See para. 1.33 on key features of ecosystem accounting that allow it to support and extend other measurement frameworks.
9. ¶39 SEEA Ecosystem Accounting (2021), Table 6.3.
0. ¶40 SEEA Ecosystem Accounting (2021), para. 6.97.
1. ¶41 Millennium Ecosystem Assessment (2005), *Ecosystems and Human Well-being: Synthesis*, definition of cultural services.
2. ¶42 IPBES (2019), *Global Assessment Report on Biodiversity and Ecosystem Services*, framing of nature's contributions to people, including non-material contributions (NCP 15–17).
3. ¶43 Haines-Young, R. and Potschin, M.B. (2018), *Common International Classification of Ecosystem Services (CICES) V5.1*, Section 4 (Cultural services).
4. ¶44 SEEA Ecosystem Accounting (2021), Chapter 6, paras. 6.51 and 6.95–6.100.
5. ¶45 SEEA Ecosystem Accounting (2021), para. 6.97.
6. ¶46 TNFD Recommendations (2023), Annex 2 Glossary, definition of "Local Communities."

DRAFT

Governance Accounts

Provides guidance on compiling governance accounts for ocean accounting, documenting institutional arrangements.

Version 0.9.1 **Status** Draft **Stability** Emerging

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

OUTCOME

This Circular provides guidance on compiling governance accounts for ocean accounting, documenting institutional arrangements, legal frameworks, and policy instruments that shape ocean management. Upon completing this Circular, readers will understand how to systematically record and classify the governance structures that apply to marine areas, including the multi-level framework established by the United Nations Convention on the Law of the Sea (UNCLOS), regional fisheries management arrangements, and national marine spatial planning instruments. The accounts enable analysis of governance effectiveness and support linkages between ocean accounting and policy evaluation frameworks, including SDG 16 (Peace, Justice and Strong Institutions) and SDG 14 (Life Below Water). The guidance integrates with the wider Ocean Accounts framework described in TG-0.1 General Introduction and the statistical standards outlined in TG-0.2 Standards Overview. The governance structures documented using this guidance provide the institutional context needed for marine spatial planning (TG-1.2 Marine Spatial Planning) and the jurisdictional framework for accounting in deep-sea areas beyond national jurisdiction (TG-6.6 Deep Sea and ABNJ).

Section 3.3.5 carries the COFOG concordance for ocean-related government expenditure, including the classes that are only partly ocean-related and the ocean-share apportionment they require. It is the source of the expenditure figures presented in budget submissions under TG-1.1 OA and National Budget Processes Section 3.7.

Governance accounts connect to several other accounts in the ocean accounting framework. They inform the policy decisions recorded in marine spatial plans (TG-1.2) and provide the management intensity data needed for MPA effectiveness assessment (TG-1.3 Marine Spatial Management (including MPAs)). They supply the institutional context for social accounts (TG-3.5 Social Accounts), where the governance rules documented here shape distributional outcomes, and for ocean economy accounts (TG-3.3 Economic Activity), where regulatory regimes influence the structure and composition of economic activity in marine sectors. They also draw on administrative data sources (TG-4.3 Administrative Data), including official gazettes, licensing databases, budget documents, and enforcement records that form the empirical basis for governance compilation.

Important Note: Governance accounting for ocean systems is an emerging field. Whilst this Circular provides a conceptual framework and initial methodological guidance, standardised classifications and compilation approaches are still under development. Practitioners should treat this guidance as provisional and anticipate refinements as experience accumulates across implementing countries. The Emerging badge assigned to this Circular reflects this provisional status. All guidance should be interpreted with caution and adapted to national circumstances.

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 3
3.1 Institutional Arrangements 4
3.2 Legal Frameworks 8
3.3 Policy Instruments 10
3.4 Governance Effectiveness 22
3.5 Compilation considerations 25
3.6 Worked Example 27
4. Acknowledgements 34
Footnotes 34

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Governance Accounts (2026) (GOAP Technical Guidance on Ocean Accounting, TG-3.7, v0.9.1). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-3/3-7-governance/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

1. Outcome

¶1 This Circular provides guidance on compiling governance accounts for ocean accounting, documenting institutional arrangements, legal frameworks, and policy instruments that shape ocean management. Upon completing this Circular, readers will understand how to systematically record and classify the governance structures that apply to marine areas, including the multi-level framework established by the United Nations Convention on the Law of the Sea (UNCLOS), regional fisheries management arrangements, and national marine spatial planning instruments. The accounts enable analysis of governance effectiveness and support linkages between ocean accounting and policy evaluation frameworks, including SDG 16 (Peace, Justice and Strong Institutions) and SDG 14 (Life Below Water). The guidance integrates with the wider Ocean Accounts framework described in **TG-0.1 General Introduction** and the statistical standards outlined in **TG-0.2 Standards Overview**. The governance structures documented using this guidance provide the institutional context needed for marine spatial planning (**TG-1.2 Marine Spatial Planning**) and the jurisdictional framework for accounting in deep-sea areas beyond national jurisdiction (**TG-6.6 Deep Sea and ABNJ**).

¶2 Section 3.3.5 carries the COFOG concordance for ocean-related government expenditure, including the classes that are only partly ocean-related and the ocean-share apportionment they require. It is the source of the expenditure figures presented in budget submissions under **TG-1.1 OA and National Budget Processes** Section 3.7.

¶3 Governance accounts connect to several other accounts in the ocean accounting framework. They inform the policy decisions recorded in marine spatial plans (TG-1.2) and provide the management intensity data needed for MPA effectiveness assessment (TG-1.3 Marine Spatial Management (including MPAs)). They supply the institutional context for social accounts (TG-3.5 Social Accounts), where the governance rules documented here shape distributional outcomes, and for ocean economy accounts (TG-3.3 Economic Activity), where regulatory regimes influence the structure and composition of economic activity in marine sectors. They also draw on administrative data sources (TG-4.3 Administrative Data), including official gazettes, licensing databases, budget documents, and enforcement records that form the empirical basis for governance compilation.

¶4 **Important Note:** Governance accounting for ocean systems is an emerging field. Whilst this Circular provides a conceptual framework and initial methodological guidance, standardised classifications and compilation approaches are still under development. Practitioners should treat this guidance as provisional and anticipate refinements as experience accumulates across implementing countries. The Emerging badge assigned to this Circular reflects this provisional status. All guidance should be interpreted with caution and adapted to national circumstances.

2. Requirements

¶1 This Circular requires familiarity with:

- ¶2 **TG-0.1 General Introduction to Ocean Accounts** – for the conceptual framework and key components of Ocean Accounts, including the relationship between environmental and economic accounting frameworks
- ¶3 **TG-0.2 Standards Overview** – for the international statistical standards underpinning ocean accounting, including SNA 2025, SEEA, and classification systems

3. Guidance Material

DRAFT

¶1 **Scope**

¶2 TG-3.7 owns the governance account tables: the institutional inventory, the marine zone and protected-area accounts, enforcement and compliance measures, and the government ocean expenditure and revenue accounts — expenditure by COFOG function and institutional sector, the EPEA-adapted environmental protection expenditure account, environmental taxes, resource rent, and administrative service revenue. It cross-refers to **TG-2.13** for the indicators derived from these accounts, **TG-3.14** for data governance and ethics, and **TG-1.1** and **TG-1.12** for the budget processes that consume the expenditure accounts.

3.1 Institutional Arrangements

¶1 Governance accounts document the institutional arrangements that govern ocean areas and resources. These arrangements operate across multiple scales (international, regional, national, and local) and involve actors including governments, intergovernmental organisations, regional bodies, and customary governance systems. The institutional mapping compiled through governance accounts provides the context for the spatial planning processes described in TG-1.2 Marine Spatial Planning, which depend on clear documentation of jurisdictional authority and institutional responsibilities within the accounting area.

3.1.1 The UNCLOS framework

¶1 The United Nations Convention on the Law of the Sea (UNCLOS), adopted in 1982, establishes the fundamental legal framework for ocean governance. UNCLOS creates a hierarchical system of maritime zones, each with distinct governance implications that can be recorded in accounting frameworks[1].

¶2 *Table 3.7.1: UNCLOS maritime zones and accounting treatment*

Zone	Distance from Baseline	Key Rights	Accounting Treatment
Internal waters	Inside baseline	Full sovereignty	National territory
Territorial sea	0–12 nm	Full sovereignty	National territory
Contiguous zone	12–24 nm	Customs, fiscal, immigration, sanitary	National jurisdiction
EEZ	0–200 nm (regime applies beyond territorial sea)	Resource rights	National resource sovereignty
Continental shelf	Seabed to 200/350 nm	Seabed resources	National seabed rights
High seas	Beyond 200 nm	Freedom of navigation	No national ownership
The Area	Deep seabed beyond jurisdiction	Common heritage	ISA administration

DRAFT

¶3 **Territorial Sea:** Extends up to 12 nautical miles from baselines, where the coastal State exercises "sovereignty…over the territorial sea…subject to this Convention and to other rules of international law" (UNCLOS Article 2)[2]. Within this zone, the coastal State has full regulatory authority, including over navigation (subject to innocent passage), fisheries, and environmental protection.

¶4 **Exclusive Economic Zone (EEZ):** Extends up to 200 nautical miles from baselines, where the coastal State has "sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living" (UNCLOS Article 56)[3]. The EEZ regime balances coastal State resource rights with freedoms of navigation, overflight, and submarine cable laying enjoyed by all States. SDG indicator 14.2.1 specifically addresses the "Proportion of national exclusive economic zones managed using ecosystem-based approaches"[4].

¶5 **Continental Shelf:** The seabed and subsoil extending beyond the territorial sea throughout the natural prolongation of the land territory, where the coastal State exercises sovereign rights for ex-

ploring and exploiting natural resources (UNCLOS Articles 76-77)[5]. For extended continental shelves beyond 200 nautical miles, claims must be submitted to the Commission on the Limits of the Continental Shelf.

¶6 **High Seas:** Areas beyond national jurisdiction where "no State may validly purport to subject any part of the high seas to its sovereignty" (UNCLOS Article 89)[6]. The high seas are governed by the principle of freedom of the seas, including freedom of navigation, fishing (subject to conservation obligations), and scientific research. Governance accounts for high seas areas require coordination with the frameworks described in TG-6.6 Deep Sea and ABNJ, which addresses accounting for areas beyond national jurisdiction in detail, including the role of sectoral management bodies and the emerging BBNJ Agreement provisions for area-based management tools.

¶7 **The Area:** The seabed and ocean floor beyond national jurisdiction, together with its resources, which are "the common heritage of mankind" (UNCLOS Article 136)[7]. Activities in the Area are governed by the International Seabed Authority (ISA), established under UNCLOS Part XI. The ISA has developed regulations for prospecting and exploration of polymetallic nodules, polymetallic sulphides, and cobalt-rich ferromanganese crusts. The governance framework for the Area is further discussed in TG-6.6 Deep Sea and ABNJ.

¶8 Governance accounts should document the spatial extent of each maritime zone within the accounting area, the governmental institutions responsible for management within each zone, and the legal instruments that operationalise UNCLOS provisions domestically. This spatial documentation relates to the delineation of ecosystem accounting areas discussed in TG-0.1 and the extent accounting approaches in SEEA EA Chapter 4.

3.1.2 Multi-level governance structures

¶1 Ocean governance typically involves multiple institutions operating at different scales. Governance accounts should document:

¶2 **International organisations:** Bodies with mandates relevant to ocean management, including the International Maritime Organization (IMO) for shipping, the Food and Agriculture Organization (FAO) for fisheries, the Intergovernmental Oceanographic Commission (IOC) for marine science, and the International Seabed Authority (ISA) for deep-sea mining.

¶3 **Regional organisations:** Regional Fisheries Management Organizations (RFMOs) that manage shared fish stocks across national boundaries, Regional Seas Programmes under UNEP, and regional economic commissions with ocean-related mandates. UNCLOS specifically encourages cooperation through regional organisations: "States shall seek, either directly or through appropriate subregional or regional organizations, to agree upon the measures necessary to coordinate and ensure the conservation and development of such stocks" (UNCLOS Article 63)[8]. States bordering enclosed or semi-enclosed seas have specific cooperation obligations under UNCLOS Article 123.

¶4 Level, mandate (function) and spatial coverage are recorded as independent attributes of each institution (Table 3.7.2 template; Table 3.7.3 worked columns). The level at which an institution sits does not determine its mandate or its spatial footprint. These allocations vary widely between unitary and federal systems: coastal zone management is national in many unitary states, whilst environmental protection or fisheries is often devolved to provinces or states in federations. Compilers should therefore populate the register from their own jurisdiction's legal instruments rather than infer a level from a mandate. Delegations, coordination arrangements and transfers between institutions are recorded as flows between stocks (see TG-2.13 Governance and Institutional Indicators), not as a hierarchy of command descending from international bodies: under UNCLOS the coastal State's sovereign rights in the territorial sea, EEZ and continental shelf are original, not delegated downward. Where formal mandate and operative authority diverge, compilers should record both the de jure mandate and the de facto operative rule (Section 3.6.4).

DRAFT

¶5 **National institutions:** Government ministries, agencies, and statutory bodies responsible for ocean management, including fisheries departments, maritime authorities, environmental protection agencies, and coastal zone management bodies. The Classification of the Functions of Government (COFOG) provides a framework for classifying government expenditure by function, with categories relevant to ocean governance including 04.2 (Agriculture, Forestry, Fishing and Hunting), 05.4 (Protection of Biodiversity and Landscape), and 05.6 (Environmental Protection n.e.c.)[9].

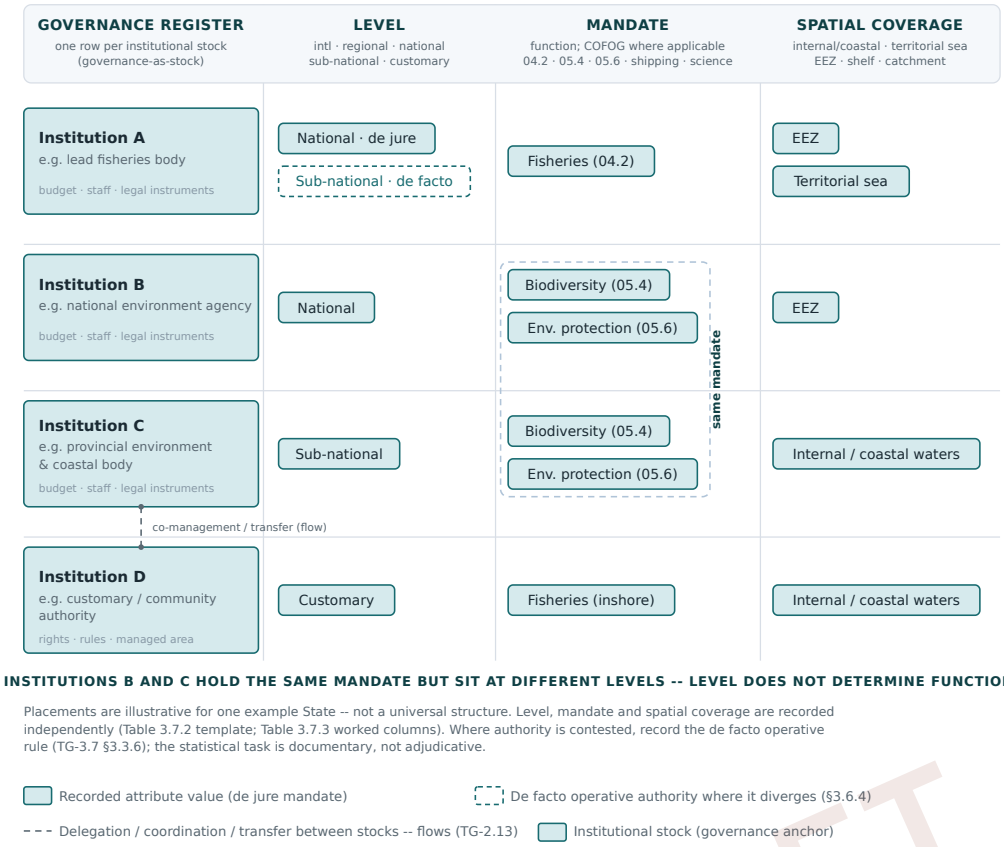
¶6 **Subnational and local institutions:** Provincial, state, and local governments with ocean management responsibilities, as well as customary governance institutions that may have traditional authority over marine areas and resources. Where customary marine tenure systems apply, the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP)[10] is the overarching international rights instrument: Articles 25–26 affirm the rights of indigenous peoples to their lands, territories, and resources including marine areas, and Article 32 affirms their right to determine priorities for the use and development of those territories. Compilers incorporating customary governance institutions into the governance account should document UNDRIP alignment and refer to **TG-3.6 Traditional Knowledge Accounts** for detailed customary marine tenure compilation methodology.

¶7 **Co-management arrangements:** Partnerships between government agencies and resource users, including fishing communities, tourism operators, and Indigenous peoples, that share management responsibilities. Co-management arrangements are particularly important for fisheries governance. See TG-1.5 Fisheries Management for related guidance.

3.1.3 Accounting for institutional arrangements

¶1 Governance accounts should compile inventories of institutions with ocean management responsibilities. Each institution is recorded once as an institutional stock and then tagged independently on three axes that together locate it within the governance register (Figure 3.7.1): level, mandate (function) and spatial coverage. Table 3.7.2 presents a suggested template for organising such inventories. The template is indicative rather than prescriptive, and compilers should adapt the structure to national circumstances and data availability.

DRAFT



DRAFT

Figure 3.7.1 Each governance institution is one stock tagged independently on Level, Mandate and Spatial coverage -- axes that do not determine one another. Placements are illustrative; dashed ties are delegation flows, not a command hierarchy.

Source: TG-3.7 §3.1.2, §3.3.6 and Tables 3.7.2--3.7.3 (institutional inventory template and worked columns); SEEA-EA (2021) institutional arrangements for ecosystem accounting; COFOG 04.2 / 05.4 / 05.6.

¶2 *Table 3.7.2: Suggested template for institutional inventory*

Field	Description	Example
Institution name	Official name	Ministry of Fisheries
Organizational type	Government department, statutory authority, intergovernmental organization, etc.	Statutory authority
Geographic scope	Specific maritime zones, ecosystem types, or management areas	EEZ and territorial sea
Functional scope	Fisheries, environment, shipping, research, etc.	Fisheries management and licensing
Legal basis	Legislation or instrument establishing authority	Fisheries Act 2005, s. 12
Relationships	Subordination, coordination, advisory links to other institutions	Reports to Ministry of Environment
Resource allocation	Budget and personnel where available	Annual budget: USD X million; N staff

Field	Description	Example
Co-management sub-template		
Arrangement type	Formal agreement, MOU, statutory co-management, informal protocol	Formal joint management agreement
Partner organizations	Name(s) of non-government partner(s)	Coastal Fishers Association
Geographic scope of arrangement	Maritime zones or areas covered by the co-management arrangement	Territorial sea, 0–3 nm
Duration	Start date and end date or ongoing	2022–2027
Decision-making rights per party	Description of which decisions each party controls or shares	Government sets TAC; community enforces access rules
Monitoring obligations	Which party is responsible for monitoring, frequency, and reporting	Joint annual stock survey; community daily log
SDG 14.b.1 (variable 3)	Whether this arrangement satisfies the criterion for small-scale fisher participation in decision-making	Yes / No / Partial

¶3 *Note: The co-management sub-template should be updated annually at each account compilation. The SDG 14.b.1-linked participation variable (variable 3) should be reviewed biennially in alignment with the FAO Code of Conduct for Responsible Fisheries (CCRF) questionnaire cycle. The participation mechanism field should record whether the arrangement satisfies SDG 14.b.1 variable (3): existence of mechanisms through which small-scale fishers contribute to decision-making processes. See FAO (2024)[11] and FAO (2015)[12] for the classification of co-management types consistent with the SSF Guidelines (Part 5).*

¶4 This institutional mapping provides the foundation for analysing governance coverage, identifying gaps, and assessing coordination mechanisms.

3.2 Legal Frameworks

¶1 Legal frameworks establish the rules that govern activities in marine areas. Governance accounts should document the hierarchy of legal instruments across international, regional, national, and local levels.

3.2.1 International legal instruments

¶1 Beyond UNCLOS itself, numerous international agreements create legal obligations relevant to ocean governance:

¶2 **Fisheries law:** The UN Fish Stocks Agreement (1995) elaborates UNCLOS provisions on straddling and highly migratory stocks, requiring conservation and management measures based on the precautionary approach and best scientific evidence[13]. The FAO Code of Conduct for Responsible Fisheries (1995) provides voluntary standards for sustainable fishing practices. For detailed treatment of fisheries governance, see TG-1.5 Fisheries Management.

¶3 **Environmental protection:** The Convention on Biological Diversity (CBD) applies to marine areas within national jurisdiction, with recent decisions under the Kunming-Montreal Global Biodiversity Framework calling for protection of 30% of marine areas by 2030[14]. The London Convention and Protocol regulate marine dumping. Regional agreements such as OSPAR (North-East Atlantic) and the Barcelona Convention (Mediterranean) establish regional obligations for marine environmental protection.

¶4 **Genetic resources and access and benefit-sharing:** The Nagoya Protocol on Access and Benefit-Sharing (2010), adopted under the CBD, establishes binding obligations for access to genetic resources and the fair and equitable sharing of benefits arising from their utilisation[15]. The Nagoya Protocol is directly relevant to governance accounts that include marine genetic resources

within national jurisdiction: compilers should record national ABS legislation, competent national authorities, and any bilateral ABS agreements for marine species as part of the legal framework inventory. The Nagoya Protocol also provides the multilateral template for the BBNJ Agreement's Part II provisions on marine genetic resources in areas beyond national jurisdiction. The two instruments are therefore complementary for compilers working across jurisdictional boundaries. Monetary valuation of ABS benefit streams is outside the scope of this Circular. ABS instruments are recorded as governance framework conditions, not as balance sheet assets (consistent with the treatment established for treaty commitments generally in Section 3.2.1).

¶5 **Indigenous rights:** The United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP, 2007)[10] provides the overarching international framework for the rights of indigenous peoples over their lands, territories, and resources, including marine areas. UNDRIP Articles 25–26 affirm the rights of indigenous peoples to their lands, territories, and resources, including marine areas, and Article 32 affirms their right to determine priorities for the development and use of those territories. Governance accounts that document customary marine governance institutions should record UNDRIP alignment in the legal framework inventory alongside national legislation recognising customary marine tenure. See TG-3.6 Traditional Knowledge Accounts for detailed customary marine tenure compilation methodology.

¶6 **Maritime security and safety:** IMO conventions address vessel safety (SOLAS), marine pollution from ships (MARPOL), and related matters. Port State control regimes enable enforcement of international shipping standards.

¶7 **New instruments:** The BBNJ Agreement establishes new governance mechanisms for high seas areas, including provisions for marine protected areas, environmental impact assessment, and marine genetic resources[16]. The BBNJ Agreement entered into force on 17 January 2026. For current ratification status, compilers should consult the United Nations Treaty Collection directly, as membership numbers change frequently. Governance accounts should document the country's ratification status and monitor COP decisions as they emerge.

DRAFT

> *BBNJ monitoring checklist (subject to revision following COP1 outcomes)*
> *Compilers should track the following five items annually:*
> 1. *¶8 National ratification status and implementing legislation (update when legislation is enacted or amended)*
> 2. *¶9 COP decisions that create new governance obligations (e.g., area-based management tool designations, EIA thresholds)*
> 3. *¶10 ABNJ marine protected area designations established under BBNJ Part III*
> 4. *¶11 Benefit-sharing arrangements for marine genetic resources under BBNJ Part II, including digital sequence information provisions*
> 5. *¶12 National ABS implementing legislation and any bilateral ABS agreements concluded for marine genetic resources in areas beyond national jurisdiction (cross-reference Nagoya Protocol national framework)*
>
> *Version note: This checklist will require revision following the first Conference of the Parties (COP1). The governance architecture for area-based management tools and EIA thresholds remains undetermined pending COP1 decisions.*

¶13 For the application of BBNJ governance provisions to deep-sea accounting, see TG-6.6 Deep Sea and ABNJ.

¶14 **Treaty compliance recording.** For RFMOs and other multilateral treaties, governance accounts should record compliance status in the institutional inventory (Table 3.7.3) as an ordinal categorical field: full compliance, partial compliance, or non-compliance. The source for each compli-

ance rating should be the relevant RFMO annual compliance monitoring report (e.g., WCPFC CMM 2023-04 for the Western and Central Pacific)[17]. Treaty obligations are governance framework conditions, not economic assets, and should not be assigned a monetary value in governance accounts. Under SNA 2025 and SEEA-EA (2021), treaty commitments are not recognised as balance sheet assets because they do not individually generate measurable economic benefits that can be controlled separately[18].

3.2.2 National legislation

¶1 Domestic legal frameworks translate international obligations into enforceable national law. Governance accounts should document:

¶2 **Primary legislation:** Acts of parliament or equivalent instruments that establish the legal framework for ocean management, including fisheries acts, maritime zones acts, environmental protection acts, and marine spatial planning legislation.

¶3 **Secondary legislation:** Regulations, rules, and orders made under primary legislation that provide detailed implementation requirements, such as fishing licence conditions, pollution discharge standards, and protected area management rules.

¶4 **Customary law:** In some jurisdictions, customary marine tenure systems and traditional governance practices have legal recognition and should be included in governance accounts. See TG-3.6 Traditional Knowledge Accounts for guidance on documenting customary governance systems.

3.2.3 Accounting for legal frameworks

¶1 Legal framework accounts should compile inventories of applicable legal instruments, classified by:

- ¶2 Instrument type (treaty, act, regulation, customary law)
- ¶3 Jurisdictional level (international, regional, national, subnational)
- ¶4 Thematic scope (fisheries, environment, shipping, etc.)
- ¶5 Geographic application (specific maritime zones or management areas)
- ¶6 Entry into force and amendment history
- ¶7 Implementation status and enforcement mechanisms

DRAFT

¶8 SDG indicator 14.c.1 specifically measures "Number of countries making progress in ratifying, accepting and implementing through legal, policy and institutional frameworks, ocean-related instruments that implement international law, as reflected in the United Nations Convention on the Law of the Sea"[19]. Governance accounts can provide the systematic documentation needed for such reporting.

3.3 Policy Instruments

¶1 Beyond legal frameworks, ocean governance employs diverse policy instruments to achieve management objectives. These instruments can be classified using frameworks from environmental economics and policy analysis.

3.3.1 Regulatory instruments

¶1 **Spatial management:** Marine Protected Areas (MPAs) and other area-based conservation measures restrict or regulate activities within defined geographic boundaries. The IUCN defines protected areas as "clearly defined geographical spaces, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature"[20]. Other Effective Area-Based Conservation Measures (OECMs) achieve conservation outcomes through management regimes not primarily intended for conservation, such as fisheries closures or military exclusion zones. For detailed guidance on MPA accounting, see TG-1.3 Marine Spatial Management (including MPAs).

¶2 **MPA governance account template.** Table 3.7.5 presents a suggested per-MPA record template that provides the governance data layer for effectiveness assessment under IUCN Green List criteria and GBF Target 3 reporting.

¶3 *Table 3.7.5: MPA governance account template*

Field	Description	Example
MPA name	Official designated name	Coral Atoll Marine Reserve
Designation date	Date of legal establishment	2019-03-15
IUCN category	Management category I–VI	IV (Habitat/Species Management Area)
Area (km²)	Total designated area	12,500
Management plan status	Approved / Draft / None	Approved (2020)
Zoning	Number and type of management zones (Core / Buffer / Transition)	3 zones: no-take core (2,500 km²), buffer (5,000 km²), sustainable use (5,000 km²)
Managing authority	Institution(s) responsible	National MPA Authority
Staffing (FTE)	Full-time equivalent staff assigned	8
Annual budget (USD)	Operational budget for the MPA	450,000
Enforcement capacity	Patrol assets and surveillance systems	1 patrol vessel, no VMS
Key legal instruments	Legislation and regulations establishing and governing the MPA	Marine Protected Areas Act 2019, s. 12; Management Plan Regulation 2020
OECM status	Whether the area qualifies as an OECM rather than a formally designated MPA	Not applicable (formally designated)
METT score tier	Management Effectiveness Tracking Tool score: Low (0–33) / Medium (34–66) / High (67–100)	Medium (score: 52)
GD-PAME assessment date	Date of most recent METT submission to GD-PAME on Protected Planet	2024-07
IUCN Green List status	Certified / In progress / Not assessed	In progress

DRAFT

¶4 *Note: METT-4 (2020)[21] produces a composite score across 38 parameters on a 0–3 scale, submitted to GD-PAME on Protected Planet. The IUCN Green List Standard Version 1.1[22] assesses sites across good governance, sound design and planning, effective management, and successful conservation outcomes. Both tools are identified as complementary indicators for the "effectively conserved and managed" element of GBF Target 3 under CBD Decision 15/5[23]. GD-PAME (Protected Planet) is the primary data source for METT scores and assessment dates.*

¶5 **Access controls and access rights inventory.** Licensing and permitting systems regulate who can conduct activities in marine areas. UNCLOS requires coastal States to establish laws and regulations relating to fishing in the EEZ, including "licensing of fishermen, fishing vessels and equipment" (UNCLOS Article 62)[24]. Governance accounts should compile a systematic access rights inventory covering:

- ¶6 **Fishing licences and quota allocations:** The number, type, and conditions of fishing licences issued; the total allowable catch and its allocation among domestic commercial, artisanal, and foreign fleets; and any individual transferable quota (ITQ) holdings. SDG indicator 14.b.1 measures "Progress by countries in the degree of application of a legal/regulatory/policy/institutional framework which recognizes and protects access rights for small-scale fisheries"[25]. Governance accounts should document the frameworks that this indicator assesses.

- ¶7 **Aquaculture permits:** Permits for marine aquaculture operations, including species, location, and operational conditions.
- ¶8 **MPA access permits:** Where MPAs restrict access, records of permits for research, tourism, or traditional use within managed zones.
- ¶9 **Coastal land tenure records:** Foreshore leases, reclamation permits, and coastal land titles that determine access to the land-sea interface.
- ¶10 **ABS permits and benefit-sharing agreements:** Permits issued under national ABS legislation for access to marine genetic resources within national jurisdiction, together with any associated benefit-sharing agreements. These are classified as operational authorisations (flow data compiled annually), consistent with the treatment of treaty commitments as governance framework conditions rather than balance sheet assets. No monetary valuation of ABS benefit streams is required in governance accounts.

¶11 **Transparency and public disclosure.** Governance accounts should record the existence and accessibility of key public disclosure mechanisms, as these are a core accountability dimension relevant to IUU fishing prevention (SDG 14.6.1) and public trust. Compilers should record three binary governance disclosure indicators:

1. ¶12 **Public fishing licence register** – whether a public register of issued fishing licences exists (yes/no). If yes, note the access modality (e.g., online database, official gazette, available on request).
2. ¶13 **EEZ access agreement publication policy** – whether a formal policy exists for publishing EEZ access agreements concluded with foreign fleets (yes/no). If yes, note any exemptions (e.g., commercial sensitivity, national security).
3. ¶14 **Public seabed lease register** – whether a public register of seabed leases exists (yes/no).

¶15 Binary scoring (yes/no) is the standard for first-generation accounts. Graded scoring (e.g., full disclosure / partial / summary-only) is optional where more detailed assessment is feasible. Where a country has legitimate confidentiality grounds for non-disclosure of specific agreement details under national law, the record should state "exempted" rather than "not disclosed," with a note on the applicable legal basis.

¶16 **Classification of access rights: asset-type rights versus operational authorisations.** Not all access rights have the same accounting treatment. Compilers should distinguish:

- ¶17 **Asset-type rights** (e.g., ITQs, tenure rights, foreshore leases): These have characteristics of tradeable assets that can be valued and tracked as stocks, with changes recorded as other volume changes or revaluations in opening/closing balance accounts. Cross-reference SEEA CF Chapter 5 on environmental asset accounts [26] for the asset treatment of resource access rights.
- ¶18 **Operational authorisations** (e.g., annual fishing licences, seasonal permits, ABS permits): These are flow data compiled annually. They do not carry capital value in their own right and should be recorded as annual flows rather than balance sheet entries.

¶19 Under SNA 2025, ITQ holdings are not recorded as separate balance sheet assets. The value attributable to ITQ rights is consolidated into the fish stock asset (AN12 – biological resources) rather than recorded as a separate contractual asset. Where ITQ markets exist, market quota prices provide a bottom-up method for valuing the fish resource stock. The access rights inventory (Table 3.7.3) records ITQ characteristics (quota volume, species, transferability) as descriptive metadata linked to the stock account, not as a standalone asset line. The OECD Measuring Natural Resources compilation guide (2025) [27] and SEEA-AFF (2020) [28] are consistent with this approach.

¶20 This access rights inventory provides the governance data that TG-3.5 Social Accounts Section 3.7.2 draws upon when assessing equity in access to ocean resources. The governance rules documented here shape the distributional outcomes recorded in social accounts.

DRAFT

¶21 **Output controls:** Catch limits, quotas, and harvest control rules regulate the quantity of resources that can be extracted. Total Allowable Catch (TAC) systems allocate catch rights among users, whilst Individual Transferable Quotas (ITQs) create tradeable property rights in fisheries.

¶22 **Technical measures:** Gear restrictions, minimum size limits, closed seasons, and other technical measures shape how activities are conducted to reduce environmental impacts.

¶23 **Compliance, enforcement, and monitoring.** Governance accounts should document the compliance and enforcement mechanisms associated with regulatory instruments. Table 3.7.6 presents a structured template for recording enforcement metrics. Where complete data are not available, compilers should document whichever metrics are obtainable and note significant gaps.

¶24 *Table 3.7.6: Enforcement and compliance metrics template*

Metric	Description	Typical source
Patrol vessel coverage	Vessel-hours per 1,000 km² per year	Maritime authority operational records
VMS coverage rate	Percentage of licensed vessels with operational Vessel Monitoring Systems	Fisheries department VMS database
Inspection rate	Inspections per 1,000 vessel-days in the accounting period	Maritime authority / fisheries enforcement records
Infringement detection rate	Detected infringements per 1,000 vessel-days	Enforcement agency case records
Prosecution rate	Percentage of detected infringements resulting in formal sanctions	Judicial records / enforcement agency
Licence compliance rate	Percentage of licence holders meeting all reporting requirements	Fisheries department licensing database

¶25 These enforcement data are typically drawn from administrative records held by fisheries management, maritime, and environmental protection agencies. Whilst complete compliance data may not be available in all jurisdictions, documenting the extent and nature of enforcement activity provides context for assessing the effectiveness of regulatory instruments. The enforcement metrics compiled here feed directly into the MPA effectiveness assessments described in TG-1.3.

DRAFT

3.3.2 Economic instruments

¶1 **Taxes and charges:** Resource rent taxes, fishing levies, and user fees can internalise environmental costs and generate revenue for ocean management. The SEEA Central Framework addresses environmental taxes and subsidies within the accounting framework[26]. Compilers should note that these instruments are not all taxes in the accounting sense: a payment for access to a government-owned resource is rent, and a fee that buys a commensurate administrative service is a sale of services. The three-way test and the corresponding revenue tables are set out in Section 3.3.5 (Table D).

¶2 **Subsidies:** Government payments that affect fishing capacity, aquaculture development, or other ocean activities. SDG Target 14.6 calls for prohibition of "fisheries subsidies that contribute to overcapacity and overfishing"[29]. Governance accounts should document the type, magnitude, and recipients of ocean-related subsidies.

¶3 **Subsidy classification.** In practice, many government transfers simultaneously serve multiple purposes (e.g., food security, rural employment, and fishing capacity support). Unambiguous classification as "harmful," "beneficial," or "neutral" is therefore difficult. Compilers should apply the FAO fisheries subsidies typology[30], which distinguishes capacity-enhancing, beneficial, and ambiguous categories, as the primary classification reference. For a multi-purpose transfer with both marine and terrestrial components (e.g., a fuel subsidy applying to all engine types), the marine share should be apportioned using the best available proxy, for example the proportion of fuel sales attributable to registered fishing vessels in national fuel supply data. FAO FishStatJ[31] is identified

as the recommended starting-point data source for subsidy magnitudes. The OECD Producer Support Estimate (PSE) methodology provides an alternative framework where FishStatJ data are incomplete.

¶4 **Payment for ecosystem services:** Schemes that compensate resource users for providing ecosystem services, such as payments to fishing communities for protecting spawning areas or mangrove conservation incentives. These relate to ecosystem services accounting discussed in TG-2.4 Ecosystem Goods and Services.

¶5 **Conservation finance:** Blue bonds, debt-for-nature swaps, and other financing mechanisms that mobilise private capital for ocean conservation. See TG-1.7 Multilateral Finance and TG-1.8 Project Finance for related guidance on financing instruments.

3.3.3 Informational instruments

¶1 **Monitoring and reporting requirements:** Obligations to collect and report data on activities, catches, and environmental conditions, including Vessel Monitoring Systems (VMS) for fishing vessels. These monitoring systems generate data that feeds into the data collection approaches discussed in Section 4 of the Technical Guidance.

¶2 **Certification and labelling:** Market-based schemes that differentiate products based on sustainability criteria, such as Marine Stewardship Council (MSC) certification for fisheries.

¶3 **Environmental assessment:** Requirements for environmental impact assessment before approving development activities, and strategic environmental assessment for plans and programmes. See TG-1.6 Environmental Impact Assessment for related guidance.

3.3.4 Accounting for policy instruments

¶1 Policy instrument accounts should document:

- ¶2 Instrument type (regulatory, economic, informational)
- ¶3 Specific mechanism (MPA, licence, quota, tax, etc.)
- ¶4 Geographic scope of application
- ¶5 Target activities or resources
- ¶6 Implementing agency
- ¶7 Compliance and enforcement mechanisms
- ¶8 Linkages to legal frameworks

DRAFT

3.3.5 Compilable governance account tables

¶1 Governance accounts should, where data permit, compile quantitative tables that present governance expenditure and revenue in a format consistent with international statistical standards. The tables described in this subsection adapt four established frameworks to the ocean governance context: COFOG for government expenditure by function (Table A), SNA 2025 for institutional sector classification (Table B), the SEEA CF Environmental Protection Expenditure Account (EPEA) for environmental protection spending (Table C), and the SEEA CF treatment of environmental transactions for governance revenue (Table D). Compilers should treat these as target structures and populate whichever cells national data sources can support, documenting gaps transparently.

¶2 **Scope boundary: two distinct SEEA CF modules.** Tables A to C and Table D borrow from different parts of SEEA CF Chapter 4, and the distinction governs how they may be used. Tables A to C are *outlay* accounts: they belong to the family of environmental activity accounts, which measure the resources devoted to environmental protection and resource management and are classified by purpose using CEPA and CReMA (and, for government, by function using COFOG). Table D is a *receipts* account: it belongs to the environmental transactions module, which records taxes, subsidies and similar transfers, rent and permits, and is classified by the nature of the transaction rather

than by purpose. The two modules have different aggregates, are typically compiled by different units within a national statistical system, and are not two halves of a single balance. Three consequences follow for compilers:

1. ¶3 **Do not net receipts against outlays.** No aggregate of the form "revenue less expenditure", "net cost of governance", or "cost recovery ratio" should be presented as an accounting balance of these tables. Earmarking does not change this: where MPA access fees fund ranger staffing, the fees are recorded as receipts in Table D and the staffing as expenditure in Table C, and both entries stand at their gross value. A cost-recovery comparison may still be reported as an analytical ratio, provided it is labelled as such, sits outside the account tables, and states both gross figures.
2. ¶4 **Neither table is a subset of the other.** Table D is not the financing section of the EPEA. The adapted EPEA at Table 3.7.9 covers the production and consumption of marine environmental protection services only; it does not record the transfers and receipts that finance them.
3. ¶5 **Table D overlaps the asset accounts and must be reconciled with them.** Rent recorded in Table D is the same resource rent that underpins monetary asset valuation. See the reconciliation note under Table D.

¶6 **Table A: Government ocean governance expenditure by function (COFOG-based).** COFOG classifies government expenditure by socio-economic function (COFOG paras. 15–31). Table 3.7.7 identifies the COFOG codes most relevant to ocean governance and provides the expenditure categories that governance accounts should aim to compile. For each COFOG code, compilers should identify the responsible government agencies and apportion their expenditures to the relevant function.

¶7 Where a single agency serves multiple COFOG functions (e.g., a ministry covering both fisheries management and aquaculture regulation), compilers should apply a two-tier apportionment decision protocol:

1. ¶8 **Programme-level data available:** Map each programme or budget line directly to the relevant COFOG code based on the programme's functional description. This is the preferred approach and produces the most transparent and verifiable compilation.
2. ¶9 **Agency-level totals only (no programme-level breakdown):** Allocate agency expenditure across COFOG codes using staffing ratios (number of FTE assigned to each function) or activity-based shares (proportion of outputs or workload attributable to each function), documenting the proxy used. This approach should be used only where programme-level data are unavailable, and the proxy method must be stated in the compilation metadata.

¶10 Where apportionment is not practicable under either tier, the expenditure should be assigned to the predominant function (COFOG para. 19). COFOG para. 22 specifically warns that environmental protection expenditures "may appear as relatively minor items in the expenditures of administrative bodies that have quite different functions". Compilers should make special efforts to identify and correctly classify all ocean-related environmental protection expenditure [32] . Section 3.6.2 demonstrates the two-tier protocol using the Ministry of Fisheries as a worked example.

¶11 *Table 3.7.7: Government ocean governance expenditure by function (COFOG-based)*

DRAFT

COFOG code	Function	Final consumption expenditure	Compensation of employees	Gross capital formation	Subsidies	Current transfers	To ou lay
03.1.0	Police services (coast guard / offshore enforcement share)						
04.2.3	Fisheries management						
04.3.2	Petroleum and natural gas (offshore share)						
04.3.5	Electricity (offshore wind share)						
04.5.2	Water transport						
04.7.3	Tourism (coastal and marine share)						
05.1.0	Marine waste management						
05.2.0	Coastal wastewater						
05.3.0	Marine pollution abatement						
05.4.0	Marine biodiversity protection						
05.5.0	R&D marine environment						
05.6.0	Environmental protection n.e.c. (ocean)						
02.1.0	Defence (naval share)						
01.3.0	General services (maritime administration, hydrographic services)						
06.3.0	Water supply (desalination)						
07.4.0	Public health services (marine food safety)						

DRAFT

COFOG code	Function	Final consumption expenditure	Compensation of employees	Gross capital formation	Subsidies	Current transfers	To ou lay
08.1.0	Recreational and sporting services (coastal recreation infrastructure)						
09.4.0	Tertiary education (maritime education and training)						
10.5.0	Unemployment (fisheries worker adjustment programmes)						
Total	**Ocean governance**						

¶12 *Note: This table presents the ocean-relevant portion of each COFOG class. Standard COFOG labels are shown with the ocean-specific share identified in parentheses. Compilers should add a methodological note explaining how the ocean-relevant portion of each COFOG class was determined.*

¶13 **Most of these classes are mixed**, covering ocean and non-ocean functions within the same code. An ocean share must be estimated for each mixed class before expenditure is summed across the table. Summing the classes without ocean-share adjustment overstates ocean-related public expenditure, in some cases by an order of magnitude — COFOG 04.2 covers all agriculture, forestry and fishing, and COFOG 09.4 all tertiary education. The two-tier apportionment protocol above applies; where neither tier is available, the ocean share should be estimated from the most relevant administrative data (the fisheries share of the agriculture ministry budget for 04.2, the proportion of police personnel assigned to maritime units for 03.1, the marine and maritime share of enrolments for 09.4) and recorded in the metadata annex, consistent with the approach in SF-MST Table 3.9 for tourism-related functions of government.[33] Classes wholly dedicated to ocean functions take an ocean ratio of 1.0, and this should be stated rather than left implicit.

¶14 Expenditure compiled on this basis is the figure presented in budget submissions under **TG-1.1 OA and National Budget Processes** Section 3.7.

¶15 **Table B: Ocean governance expenditure by institutional sector and maritime zone.** Table 3.7.8 cross-classifies ocean governance expenditure by SNA 2025 institutional sector (SNA 2025 paras. 5.27–5.28) and UNCLOS maritime zone. This table identifies which sectors bear the cost of governance in which maritime areas. The general government sector (S13) is typically the dominant funder of governance, but non-financial corporations (S11) may incur compliance costs, whilst international organisations (S2) contribute through regional cooperation mechanisms.

¶16 For the S11 (private corporations) row and the households row, zone attribution is often not feasible from aggregated data because compliance costs (e.g., VMS installation, licence fees) are incurred fleet-wide rather than by individual zone. Where vessel-level data linking effort to zone are available (e.g., from VMS logs or fishing logbooks), compilers may use effort-share proxies (such as the proportion of vessel-days spent in each zone) to apportion S11 and household compliance costs. Where effort-share data are unavailable, these rows should be left blank with an explanatory

metadata note. A simplified tier-1 version of Table 3.7.8 that aggregates all non-government sectors into a single row is appropriate for countries with limited data.

¶17 *Table 3.7.8: Ocean governance expenditure by institutional sector and maritime zone*

Maritime zone	General government			Public corps	Private corps	Households	NPISH
	Central	State/Province	Local				
Internal waters							
Territorial sea							
EEZ							
Continental shelf							
High seas / ABNJ							
Total							

¶18 **Table C: Ocean environmental protection expenditure account (EPEA-adapted).** Following the SEEA CF Table 4.4 structure (SEEA CF paras. 4.49–4.50, 4.85), Table 3.7.9 presents the national expenditure on ocean-specific environmental protection. This table distinguishes between the production of environmental protection services (by government and specialist producers) and their consumption (by users across sectors). Together these entries account for the resources devoted to marine environmental governance.

¶19 *Table 3.7.9: Ocean environmental protection expenditure account (EPEA-adapted)*

Type of expenditure	Government EP producers	Other specialist producers	Non-specialist producers	Households	General government	NPISH	Total
Marine EP specific services							
Intermediate consumption							
Final consumption							
Gross fixed capital formation							
Connected products							
Intermediate consumption							
Final consumption							
Capital formation for marine EP activities							
Marine EP transfers							
– to/from rest of world (net)							
Total national expenditure on marine EP							

DRAFT

¶20 *Classification note: In the SEEA EPEA structure, "marine EP specific services" are services whose primary purpose is marine environmental protection (e.g., MPA ranger staffing, marine pollution monitoring programmes). "Connected products" are goods and services that facilitate environmental protection but have other primary uses (e.g., fishing vessel safety equipment, coastal CCTV surveillance systems). Capital formation entries cover produced assets whose primary purpose is marine EP (e.g., patrol vessel purchase, MPA visitor centre construction). Ocean-specific examples for each row type: specific services — MPA ranger staffing, marine pollution monitoring; connected products — vessel safety equip-*

ment, coastal CCTV; capital formation — patrol vessel purchase, MPA visitor centre. Cross-reference SEEA CF paras. 4.49–4.50 for definitional authority.

¶21 **Table D: Ocean governance revenue from environmental transactions.** Table D compiles the receipts that governments collect from ocean activities. It is presented as three separate tables because the payments a compiler encounters in ocean administration fall into three different accounting categories, and only the first consists of taxes. Recording all ocean receipts as taxes overstates tax revenue, understates property income, and—because rent is the basis of monetary asset valuation—double counts against the asset accounts.

¶22 **The three-way classification test.** Before entering a payment in any part of Table D, apply the following questions in order [34]:

1. ¶23 **Is the payment made for the use of a natural resource that the government owns?** If so, it is **rent** (property income), not a tax, however the instrument is named in national legislation. Fishing access payments, offshore petroleum and mineral royalties, and seabed or foreshore leases normally fall here. Record in Table 3.7.10b.
2. ¶24 **If not, does the payer receive an administrative service commensurate with the amount paid?** If so, it is a **sale of services** (non-tax revenue). Application processing, inspection and certification, and observer-programme cost recovery normally fall here. Record in Table 3.7.10c.
3. ¶25 **Otherwise, the payment is a compulsory unrequited transfer to government: it is a tax.** Where its tax base is a physical unit with a proven negative environmental impact—energy, transport, pollution, or resources—it is an **environmental tax**. Record in Table 3.7.10a.

¶26 The test turns on the substance of the transaction, not the label. A charge called a "licence fee" may be rent, a sale of services, or a tax depending on what the payer receives, and a single instrument may need to be split where the amount plainly exceeds the cost of any service provided. Compilers should record the classification decision and its basis in the compilation metadata, and should reconcile the resulting totals with the government finance statistics for the same reference year.

¶27 *Table 3.7.10a: Ocean environmental taxes*

¶28 Environmental taxes are defined by their tax base rather than their declared purpose: a fuel tax applies to marine fuel regardless of the government's stated intent [35].

Type of tax	Taxes on products	Other taxes on production	Taxes on income	Other current taxes	Capital taxes	Total
Marine fuel taxes						
Vessel tonnage taxes						
Marine pollution and dumping taxes						
Other ocean-related environmental taxes						
Total ocean environmental taxes						

¶29 *Table 3.7.10b: Rent on marine natural resources (property income)*

Type of payment	Resource or asset	Sector paying	Amount
Domestic fishing access payments	Fish stocks		
Foreign-fleet access agreement payments	Fish stocks		
Offshore petroleum and mineral royalties	Subsoil assets		

DRAFT

Type of payment	Resource or asset	Sector paying	Amount
Aquaculture site leases	Seabed / water column		
Foreshore and seabed leases	Land and seabed		
Total rent on marine natural resources			

¶30 *Table 3.7.10c: Sales of marine administrative services (non-tax revenue)*

Type of fee	Service provided	Amount
Vessel registration and survey fees	Registration, safety survey	
Licence and permit application processing	Application assessment	
Aquaculture and discharge permit administration	Assessment, monitoring	
MPA access and visitor fees	Site access and facilities	
Observer programme cost recovery	Observer placement	
Total sales of marine administrative services		

¶31 *Reconciliation note: rent and the asset accounts.* The rent recorded in Table 3.7.10b is the same resource rent that monetary asset accounts use to value marine assets, and that fiscal analysis uses to separate income from depletion. Rent received by government is one part of the total resource rent generated by extraction; the remainder accrues to the extractor. Compilers should therefore (a) not treat the government's rent receipts as a measure of total resource rent, and (b) reconcile Table 3.7.10b against the resource rent estimates used in the monetary fish stock and subsoil asset accounts in **TG-3.1 Assets** and in the depletion calculation at **TG-1.1 Budget Processes** Section 3.4, documenting any difference. Presenting government rent receipts alongside a depletion-adjusted net income measure without this reconciliation double counts the same flow [36].

¶32 These four tables together provide an accounting framework for governance expenditure and for governance revenue, compiled and presented separately in accordance with the scope boundary set out at the head of this subsection. Section 3.6 demonstrates how to populate Table A using the worked example scenario.

DRAFT

3.3.6 Spatial classification of designated marine uses

¶1 Governance accounts produce a spatial classification of designated marine use zones: the geographic areas within which specific activities are authorised, regulated, or prohibited by governance instruments. This spatial overlay of governance designations is among the more operationally useful outputs of governance accounts, because it provides the governance data layer that marine spatial planning processes (TG-1.2) overlay with ecosystem extent to relate governance arrangements to ecological assets.

¶2 Table 3.7.11 presents a classification of designated marine use types. Each zone within the accounting area should be assigned to one or more use categories based on the governance instruments that apply to it.

¶3 *Table 3.7.11: Classification of designated marine use zones*

Ocean environmental goods and services sector (EGSS)

¶1 The expenditure accounts above record what government and others *spend* on ocean environmental protection. The EGSS account records the supply side: the industries that produce the goods and services that spending buys. The two are counterparts, and compiling one without the other leaves ocean environmental expenditure with no visible producing sector — which matters directly to **TG-1.7**, **TG-1.12** and **TG-2.6**, all of which reason about ocean environmental investment.

¶2 The ocean EGSS boundary covers producers whose output is environmental protection or resource management in the marine and coastal domain. The activity list below is the ocean subset;

the full EGSS activity classification is in the SEEA CF.

¶3 **Table 3.7.15: Ocean environmental goods and services sector account — structural template**

EGSS activity	Typical ISIC	Output	Gross value added	Employment (FTE)	Exports
Marine and coastal habitat restoration	0210, 4290, 7490	[value]	[value]	[n]	[value]
Coastal protection works (engineered and nature-based)	4291	[value]	[value]	[n]	[value]
Wastewater and ballast water treatment for marine discharge	3700, 3900	[value]	[value]	[n]	[value]
Marine waste collection, recycling and litter removal	3811, 3830	[value]	[value]	[n]	[value]
Marine environmental monitoring, survey and consultancy	7112, 7120, 7211	[value]	[value]	[n]	[value]
Marine protected area management services	8413, 9103	[value]	[value]	[n]	[value]
Low-impact and selective fishing gear manufacture	3220	[value]	[value]	[n]	[value]
Total ocean EGSS		**[Σ]**	**[Σ]**	**[Σ]**	**[Σ]**

¶4 *Table 3.7.15: Structural template of an ocean EGSS account. Most rows are partial: only the ocean-related share of the ISIC class belongs here, estimated on the same ocean-ratio basis as TG-3.3 Section 3.5 Step 4, and the ratio should be recorded per row.*

¶5 **Two boundary cautions.** First, EGSS output overlaps the ocean economy supply-use table in TG-3.3: a firm building a seawall is in both. Present them as complementary views rather than adding them, and state the overlap. Second, EGSS is defined by the *purpose* of the output, not the industry of the producer, so a shipyard's share of output that is selective gear is in scope while the rest of it is not. Where purpose cannot be separated from a producer's accounts, record the row as not estimable rather than assigning the whole producer.

DRAFT

Use category	Description	Typical governance source
Fishery management zone	Area subject to specific fisheries regulations (TAC, gear restrictions, seasonal closures)	Fisheries act, RFMO conservation measures
Aquaculture zone	Area designated for marine aquaculture operations	Aquaculture licensing regulations
Port area	Harbour, anchorage, and approaches subject to port authority jurisdiction	Port and maritime transport legislation
Shipping lane	Designated traffic separation scheme, fairway, or recommended route	IMO-approved routing measures, national maritime regulations
Tourism zone	Area designated or primarily managed for marine tourism and recreation	Tourism and coastal development legislation
Offshore energy zone	Area licensed for offshore wind, wave, tidal, or hydrocarbon extraction	Energy licensing regulations, continental shelf act
Mineral extraction area	Area licensed for seabed mining or sand/gravel extraction	Mining legislation, ISA contracts
Marine protected area	Area designated under MPA legislation (IUCN categories I–VI)	MPA act, environment act
OECM	Area achieving conservation outcomes through non-conservation management	Various (fisheries closures, military exclusion zones)

Use category	Description	Typical governance source
Military / security zone	Area restricted for defence or security purposes	Defence legislation
Undesignated	Area not subject to any specific spatial designation	Residual category

¶6 To compile this spatial classification, governance accounts should:

1. ¶7 **Assemble spatial boundaries** from the administrative records of each agency responsible for designating use zones (fisheries department for fishery zones, port authority for port areas, MPA authority for protected areas, etc.).
2. ¶8 **Reconcile overlapping designations.** Document the legal hierarchy that determines which designation takes precedence where zones overlap.
3. ¶9 **Deduplicate area statistics for GBF/SDG reporting.** Where zones overlap (e.g., an MPA that overlaps with a designated fishery zone), compilers should record all applicable designations and note the hierarchy of precedence established by national law. For GBF Target 3 and SDG 14.5.1 reporting, area statistics must be non-double-counted: dissolve overlapping polygons before calculating area totals and assign each dissolved polygon to the highest-protection IUCN category that applies. This deduplication step is consistent with the WDPA data standard [37] and the GBF monitoring framework (CBD Decision 15/5). Without polygon dissolution, area statistics will overcount protection coverage.
4. ¶10 **Record the operative governance rule where jurisdictional hierarchy is contested.** Where the hierarchy between two governance instruments or levels is unclear or actively contested (for example, where a national fisheries regulation conflicts with a customary seasonal closure, or where RFMO conservation measures have not been fully transposed into national law), compilers should record the de facto operative rule in force at the account reference date as the primary entry in the spatial classification, and document the contested or unclear status in the compilation metadata with a brief description of the competing claims. The statistical task is documentary, and this Circular does not prescribe which rule should legally prevail.
5. ¶11 **Calculate area statistics** for each use category, by maritime zone (internal waters, territorial sea, EEZ, continental shelf), to produce the cross-tabulation described in TG-1.2 Table 2.
6. ¶12 **Track changes over time** by recording the date of each designation, modification, or revocation, enabling time-series analysis of how the spatial footprint of governance evolves.

¶13 The designated use zone classification is an emerging area of practice, and the categories listed above should be adapted to national circumstances. Countries with established marine spatial plans may already maintain such classifications, whilst countries without MSP may need to compile them from disparate sector-specific administrative records.

¶14 **Management effectiveness integration.** To support the "effectively conserved and managed" element of GBF Target 3, the designated area statistics table should incorporate management effectiveness data from METT-4 scores and IUCN Green List certification status as categorical fields within Table 3.7.11 (see the management effectiveness fields in Table 3.7.5). Compilers should cross-reference GD-PAME as the data source and CBD Decision 15/5 as the reporting authority.

3.4 Governance Effectiveness

¶1 Governance accounts compile three distinct types of information that serve different analytical purposes. Governance structure indicators record which governance arrangements exist: they document the presence, type, and characteristics of institutions, legal instruments, and policy mechanisms, and are compiled as the primary content of the institutional inventory tables (Tables 3.7.2–3.7.11, Sections 3.1–3.3), analogous in function to ecosystem extent data in SEEA-EA. Governance context data capture the social circumstances (poverty, health, inclusion) and risk-resilience condi-

tions within which governance arrangements operate. These are drawn from complementary social, environmental, and economic accounts, and are typically assembled for joint presentation with governance structure data in combined analyses rather than compiled as first-order governance account entries. The placement of governance context data, whether as entries within the governance account or as contextual overlays from other accounts, remains under active methodological discussion. Compilers should document their approach explicitly where context data are incorporated. Governance effectiveness measures assess how well those arrangements work: they are analytical extensions that draw on structure data to assess coverage, coherence, compliance, adaptiveness, and participation outcomes. SEEA-EA does not define a separate governance "condition account" analogous to its ecosystem condition accounts, and the relationship between governance structure, context, and effectiveness as an integrated accounting framework remains an active research question. Effectiveness analysis therefore supplements the structural inventory without replacing it, and should be interpreted as an optional analytical layer rather than a core accounting requirement. Compilers should begin by establishing the structural inventory before incorporating context data or introducing quantitative effectiveness measures.

¶2 Standardised methods for measuring governance effectiveness in ocean contexts are still developing. Practitioners should begin with the descriptive accounts in Sections 3.1–3.3 and introduce quantitative effectiveness measures as methods and data permit. The practical entry points described below represent what practitioners can realistically compile with currently available methods and data.

3.4.1 SDG 16 and institutional effectiveness

¶1 SDG 16 calls for "effective, accountable and transparent institutions at all levels" (SDG Target 16.6) [38] . Whilst general indicators address government effectiveness (e.g., SDG indicator 16.6.1 on budget execution), ocean-specific governance effectiveness measures are less developed.

¶2 Potential dimensions for assessing ocean governance effectiveness are summarised in Table 3.4.1 below.

Dimension	Diagnostic question
Coverage	What proportion of the accounting area is covered by formal governance arrangements? Are there gaps in jurisdictional or functional coverage?
Coherence	Are governance arrangements consistent across scales and sectors? Are there conflicts or coordination failures between institutions? This relates to the discussion of cross-sectoral integration in TG-1.2 Marine Spatial Planning.
Compliance	What are rates of compliance with governance requirements? What enforcement capacity exists?
Adaptiveness	Do governance arrangements incorporate mechanisms for learning and adaptation, such as regular review cycles or adaptive management provisions?
Participation	Do governance arrangements provide for stakeholder participation in decision-making? SDG indicator 16.7.2 addresses "Proportion of population who believe decision-making is inclusive and responsive" [39] . This dimension connects to social accounting approaches in TG-3.5 Social Accounts.

3.4.2 MPA effectiveness

¶1 For Marine Protected Areas, governance accounts can document management effectiveness using established assessment frameworks. The IUCN Green List Standard establishes criteria for effective and equitably managed protected areas, organised around good governance, sound design and planning, effective management, and conservation outcomes [40] .

¶2 SDG indicator 14.5.1 measures "Coverage of protected areas in relation to marine areas," whilst indicator 14.2.1 addresses "Proportion of national exclusive economic zones managed using ecosys-

tem-based approaches"[41]. Governance accounts provide the data infrastructure for computing such indicators. See TG-1.3 Marine Spatial Management (including MPAs) for detailed guidance on MPA effectiveness assessment.

3.4.3 Linking governance to outcomes

¶1 The test of governance effectiveness is whether arrangements achieve their intended outcomes: sustainable use, ecosystem health, and equitable benefit sharing. Governance accounts should be compiled in conjunction with biophysical accounts (see TG-2.1 Biophysical Indicators) and economic accounts (see TG-3.3 Economic Activity) to enable analysis of relationships between governance arrangements and environmental and economic outcomes.

¶2 The access rights inventory (Section 3.3.1) and economic instrument rules (Section 3.3.2) provide the governance context for the equity, access, and resilience analyses in TG-3.5 Social Accounts. Compilers should ensure that governance accounts and social accounts are compiled in a coordinated manner, so that the institutional rules documented here can be linked to the distributional patterns recorded in social accounts.

¶3 Analytical approaches include:

¶4 **Comparative analysis:** Comparing outcomes across areas with different governance regimes, controlling for other factors. For example, comparing fish stock status or ecosystem condition indicators between areas subject to different management regimes within the same accounting period can indicate the influence of governance arrangements.

¶5 **Time series analysis:** Tracking changes in outcomes following implementation of governance reforms. Where governance structures change significantly between accounting periods, compilers should maintain a change log recording major reforms. The minimum change log schema should include six required fields: change date (effective date of reform), change type (legislative, institutional, spatial designation, or policy instrument), prior state (brief description), new state (brief description), relevant governance account tables affected, and data revision required (yes/no). A log entry is required whenever a change affects the classification of any entry in Tables 3.7.2–3.7.11 or the calculation of any indicator in Table 3.7.12. This enables time-series accounts to be interpreted correctly by providing the institutional context for observed changes in biophysical or economic indicators.

¶6 **Counterfactual assessment:** Estimating what outcomes would have been absent specific governance interventions. This approach is methodologically demanding but may be feasible where comparable areas with and without specific governance arrangements exist.

¶7 These analytical approaches require caution in attributing causation, as governance is only one factor among many that influence ocean outcomes. The governance-outcome analytical methods described here are still maturing, and practitioners should document analytical choices, assumptions, and limitations transparently.

3.4.4 SDG and GBF indicator mapping

¶1 Governance accounts produce outputs that directly support national reporting on several international indicator frameworks. Table 3.7.12 provides a consolidated mapping between governance account components and the SDG 14, SDG 16, and Kunming-Montreal GBF indicators that they inform. This mapping is intended as a practical reference for compilers seeking to maximise the reporting utility of their governance compilation effort.

¶2 *Table 3.7.12: Mapping governance account outputs to international indicators*

DRAFT

Indicator	Indicator description	Governance account component
SDG 14.2.1	Proportion of national EEZ managed using ecosystem-based approaches	Designated use zone classification (Section 3.3.6); governance coverage assessment (Section 3.4.1). *Note: Governance accounts provide supporting data for the official SDG 14.2.1 custodian methodology (FAO/UNEP-WCMC) but do not directly produce the official indicator. The custodian methodology applies a six-criteria ecosystem-based approaches scoring framework via a national survey instrument. Compilers should use the FAO/UNEP-WCMC methodology for official SDG reporting; governance accounts provide complementary spatial extent and management plan status evidence.*
SDG 14.5.1	Coverage of protected areas in relation to marine areas	MPA governance account (Table 3.7.5); designated use zone statistics
SDG 14.6.1	Degree of implementation of international instruments aiming to combat illegal, unreported and unregulated (IUU) fishing	Legal framework inventory (Section 3.2); compliance and enforcement metrics (Table 3.7.6)
SDG 14.b.1	Degree of application of a framework which recognizes and protects access rights for small-scale fisheries	Access rights inventory (Section 3.3.1); legal framework accounts (Section 3.2.2–3.2.3)
SDG 14.c.1	Progress in ratifying, accepting and implementing ocean-related instruments	Legal framework accounts (Section 3.2.1–3.2.3)
SDG 16.6.1	Primary government expenditures as a proportion of original approved budget	COFOG expenditure account (Table 3.7.7); budget execution data
SDG 16.7.2	Proportion of population who believe decision-making is inclusive and responsive	Participation dimension of governance effectiveness (Section 3.4.1)
GBF Target 3	30% of marine areas effectively conserved and managed by 2030	MPA governance accounts (Table 3.7.5); designated use zone classification; enforcement metrics (Table 3.7.6)
GBF Target 5	Sustainable use, harvesting and trade of wild species	Fisheries governance instruments (Section 3.3.1); access rights inventory; compliance metrics

DRAFT

3.5 Compilation considerations

3.5.1 Data sources

¶1 Governance accounts draw on diverse data sources:

- ¶2 Official gazettes and legal databases for legislative instruments
- ¶3 Government reports and organisational charts for institutional arrangements
- ¶4 Budget documents for resource allocation
- ¶5 Protected area databases (World Database on Protected Areas, national registries)
- ¶6 RFMO and international organisation records
- ¶7 Administrative records on licences, permits, and enforcement actions

¶8 For guidance on administrative data sources more generally, see TG-4.3 Administrative Data.

3.5.2 Classification challenges

¶1 Governance arrangements do not always fit neatly into standardised classifications. Challenges include:

- ¶2 Overlapping jurisdictions and shared responsibilities
- ¶3 Informal governance arrangements that lack formal legal status
- ¶4 Rapid evolution of governance frameworks
- ¶5 Variation in terminology across jurisdictions

¶6 Compilers should document classification decisions and note significant ambiguities.

3.5.3 Update frequency

¶1 Governance arrangements change less frequently than biophysical or economic variables, but significant reforms do occur. Accounts should be updated when major legislative changes occur, new institutions are established, or protected area networks are significantly modified. Where governance structures change significantly between accounting periods, the change should be documented in the institutional inventory with effective dates, enabling users to correctly interpret time-series comparisons of governance-related indicators.

¶2 Two distinct update cadences apply to governance accounts, and compilers should manage them separately:

- ¶3 **Change log update** — triggered as events occur, whenever a governance instrument is enacted, amended, or revoked and the change meets the significance threshold defined in Section 3.4.3 (any change affecting the classification of entries in Tables 3.7.2–3.7.11 or the calculation of indicators in Table 3.7.12). The change log is a continuous monitoring record, not a periodic recompilation.
- ¶4 **Full governance account recompilation** — recommended annually, but acceptable on a biennial basis where institutional capacity is constrained, provided the change log is kept current between compilations. Cross-reference Section 3.4.3 for the significance threshold definition that governs change log entries.

¶5 **Mid-year governance change protocol.** Where a major governance reform spans the accounting year (e.g., new primary legislation introduced and enacted at different points within the same year), compilers should:

1. ¶6 Record both the prior governance regime and the new regime, each with its effective date.
2. ¶7 Produce a split-year narrative note describing the period of change and the nature of the reform.
3. ¶8 Use the **year-end governance state** as the reference point for any indicator calculations (e.g., SDG 14.c.1 legal framework implementation scores) for that accounting period. This convention is consistent with the SNA 2025 principle that balance sheet accounts record asset and liability states at the end of the reference period (SNA 2025 Chapter 13)[42]. Note that SEEA-EA (2021) and the SEEA CF do not yet provide specific guidance on mid-period governance changes. The year-end convention is recommended as an editorial default pending future SEEA guidance.

DRAFT

4. ¶9 Flag the period of change in the compilation metadata so that users are aware that two governance regimes applied during the accounting year.

¶10 This protocol should be aligned with the change log recommended in Section 3.4.3. Where a country is actively reforming legislation throughout the accounting year, the split-year narrative note and the change log together provide the transparency needed for consistent time-series interpretation.

3.5.4 Minimum viable accounts in fragile and low-capacity contexts

¶1 In contexts where state authority is contested, IUU fishing is widespread, or institutional collapse has occurred, compilers may face extreme data constraints that make a full governance account uncompilable. In such contexts, a minimum viable account is preferable to no account, as it establishes a baseline that can be progressively improved and signals to users the governance conditions under which the account was compiled.

¶2 The minimum viable account floor is: at least one institution with a documented governance mandate (even if capacity-constrained) and identification of the applicable legal framework (even if unenforced). This is sufficient to compile a first-generation governance account. Where even this floor cannot be met, compilers should document the reason in compilation metadata rather than omitting the jurisdiction entirely from comparative compilations.

¶3 All accounts compiled in fragile, conflict-affected, or severely low-capacity contexts must carry a mandatory data quality flag in the compilation metadata, specifying: (a) the contextual conditions (e.g., contested state authority, widespread IUU fishing, institutional collapse), and (b) which elements of the account reflect de jure frameworks only, with limited or no evidence of de facto implementation. A typical formulation is: *"de jure only — de facto coverage unverified."*

¶4 Compilers working in these contexts should consult the World Bank Statistical Capacity Assessment frameworks and PARIS21 guidance for context-specific compilation support and capacity development resources.

DRAFT

3.6 Worked Example

¶1 This section presents a hypothetical worked example illustrating how governance accounts might be compiled for a Pacific Small Island Developing State (SIDS). All institutions, figures, and arrangements are fictional and are designed to demonstrate the accounting structures described in this Circular. Actual compilations would draw on national legal databases, budget documents, and institutional records as described in Section 3.5.1.

3.6.1 Scenario: Institutional inventory for a hypothetical Pacific SIDS

¶1 **Setting.** A hypothetical Pacific Island State with an EEZ of approximately 1.2 million km², a territorial sea of 15,000 km², and a coastline of 800 km. The population of 280,000 is predominantly coastal, with approximately 85% living within 5 km of the coast. The economy depends significantly on fisheries (tuna licensing revenue constitutes 30% of government revenue) and coastal tourism.

¶2 The following institutional inventory documents the ten principal governance institutions with ocean management responsibilities.

¶3 *Table 3.7.3: Institutional inventory — hypothetical Pacific SIDS*

No.	Institution	Level	Mandate	Spatial coverage	Annual budget (USD)
1	Ministry of Fisheries and Marine Resources	National	Fisheries management, licensing, stock assessment, aquaculture regulation	EEZ and territorial sea	USD 4.2 million
2	National Environment Service	National	Environmental protection, EIA, pollution control, biodiversity conservation	All maritime zones	USD 2.8 million
3	Maritime Authority	National	Vessel registration, port safety, maritime security, search and rescue	EEZ, territorial sea, ports	USD 1.5 million
4	Department of Tourism	National	Tourism planning, licensing, standards, coastal development oversight	Territorial sea and coast	USD 1.1 million
5	Lands and Survey Department	National	Coastal land tenure, foreshore leases, reclamation permits	Internal waters and coast	USD 0.9 million
6	National MPA Authority	National	Marine protected area designation, management, monitoring	12 designated MPAs totalling 45,000 km²	USD 1.8 million
7	Island Council — Outer Islands (x4)	Subnational	Local fisheries regulation, coastal zone management, traditional resource management	Lagoons and nearshore waters (0–3 nm) within island jurisdiction	USD 0.15 million (each)
8	Traditional Chiefs Council (Fono)	Community	Customary marine tenure, seasonal closures (rahui/tabu), conflict resolution	Customary fishing grounds (varies by village)	Not applicable (voluntary)

DRAFT

No.	Institution	Level	Mandate	Spatial coverage	Annual budget (USD)
9	Forum Fisheries Agency (regional)	Regional	Coordination of tuna management, VMS, observer programmes	Western and Central Pacific	Member contribution: USD 0.3 million/year
10	Western and Central Pacific Fisheries Commission (WCPFC)	Regional/International	Conservation and management of highly migratory fish stocks	Western and Central Pacific Ocean	Member contribution: USD 0.2 million/year

3.6.2 Compiled COFOG expenditure table

¶1 Using the institutional inventory from Table 3.7.3, the budget data can be mapped to COFOG categories to produce a compiled version of Table A (Table 3.7.7). The following table demonstrates this mapping for the hypothetical Pacific SIDS.

¶2 **Ministry of Fisheries apportionment (two-tier protocol).** The Ministry of Fisheries and Marine Resources (USD 4.2M, 85 FTE) covers fisheries management, licensing, stock assessment, and aquaculture regulation across multiple COFOG codes. Programme-level budget data are available from the Ministry's annual report and are used directly (tier 1): fisheries management operations (COFOG 04.2.3) account for 82% of the Ministry's budget; coastal environment and pollution compliance (COFOG 05.3.0) accounts for 7%; research and stock assessment (COFOG 05.5.0) accounts for 7%; and aquaculture regulation (COFOG 04.2.3, same code) is included within the management programme allocation. The remaining 4% (administration) is assigned to the predominant function (04.2.3) per COFOG para. 19. Where a single institution's budget spans multiple COFOG functions, expenditure has been apportioned based on functional composition as reported in the institution's annual report.

¶3 **Reconciliation bridge from institutional budgets to COFOG table totals.** The COFOG table total of USD 12.9M is derived from the institutional budget totals of USD 13.4M through three adjustments:

1. ¶4 **Inter-institutional transfers removed.** Regional contributions (USD 0.3M to FFA and USD 0.2M to WCPFC = USD 0.5M) appear in the Ministry of Fisheries budget (USD 4.2M) as current transfers paid to external bodies. These same contributions appear as a separate line in Table 3.7.13 (regional contributions row). To avoid double-counting, the USD 0.5M is deducted once from the COFOG total. Remaining: USD 13.4M – USD 0.5M = USD 12.9M.
2. ¶5 **Island Council budgets apportioned.** The four Island Councils (4 x USD 0.15M = USD 0.6M) are distributed across COFOG 04.2.3 (fisheries management, approximately 60% of Island Council activity = USD 0.36M) and COFOG 05.4.0 (biodiversity protection, approximately 40% = USD 0.24M), based on staffing ratios reported in Island Council annual reports (tier 2 proxy). These amounts are included within the COFOG line totals and are not shown as a separate row.
3. ¶6 **Regional contributions retained as a separate line.** The USD 0.5M in regional contributions (FFA + WCPFC) is shown as a separate line in Table 3.7.13 under current transfers to make the institutional source transparent. It is counted once in the grand total: the COFOG lines above it sum to USD 12.4M and exclude it, so it is not double counted.

¶7 *Table 3.7.13: Compiled government ocean governance expenditure — hypothetical Pacific SIDS (USD thousands)*

DRAFT

COFOG code	Function	Source institution(s)	Final consumption expenditure	Compensation of employees	Gross capital formation	Subsidies
03.1.0	Police services (coast guard / offshore enforcement share)	Inst. 3 (Maritime Authority, 83%)	420	680	150	–
04.2.3	Fisheries management	Inst. 1 (Ministry of Fisheries, 86%); Inst. 7 (Island Councils, 14%)	1,400	2,170	430	180
04.3.2	Petroleum and natural gas (offshore share)	–	–	–	–	–
04.3.5	Electricity (offshore wind share)	–	–	–	–	–
04.5.2	Water transport	Inst. 3 (Maritime Authority, 17%)	320	560	350	–
04.7.3	Tourism (coastal and marine share)	Inst. 4 (Tourism, 100%)	280	460	130	80
05.1.0	Marine waste management	Inst. 2 (Environment, 9%)	90	130	40	–
05.2.0	Coastal wastewater	Inst. 2 (Environment, 7%)	70	100	40	–
05.3.0	Marine pollution abatement	Inst. 1 (Fisheries, 7%); Inst. 2 (Environment, 5%)	120	200	60	–
05.4.0	Marine biodiversity protection	Inst. 2 (Environment, 36%); Inst. 6 (MPA Authority, 55%); Inst. 7 (Island Councils, 9%)	770	880	250	–
05.5.0	R&D marine environment	Inst. 1 (Fisheries, 7%); Inst. 2 (Environment, 25%); Inst. 5 (Lands, 11%)	200	310	70	–

DRAFT

COFOG code	Function	Source institution(s)	Final consumption expenditure	Compensation of employees	Gross capital formation	Subsidies
05.6.0	Environmental protection n.e.c. (ocean)	Inst. 2 (Environment, 18%); Inst. 5 (Lands, 100%)	260	360	90	–
02.1.0	Defence (naval share)	–	–	–	–	–
	Regional contributions (Inst. 9, 10) — counted once in the total (see reconciliation note)	Inst. 1 (current transfers to FFA and WCPFC)	–	–	–	–
Total	**Ocean governance**		**3,930**	**5,850**	**1,610**	**260**

¶8 *Note: The USD 12.9M total is derived from institutional budget totals of USD 13.4M after deducting USD 0.5M for regional contributions (see reconciliation bridge above). Source institution percentages in the third column indicate the share of that institution's budget apportioned to this COFOG line; they do not sum to 100% within a column because each institution may contribute to multiple COFOG lines.*

¶9 This compilation illustrates how the institutional inventory translates into a COFOG-structured expenditure account. The dominance of fisheries management (COFOG 04.2.3, 35% of total) and marine biodiversity protection (COFOG 05.4.0, 16%) is consistent with the hypothetical country's economic dependence on fisheries and its commitment to marine conservation.

DRAFT

3.6.3 Mapping institutions to governance dimensions

¶1 Using the governance effectiveness dimensions described in Section 3.4.1, compilers can assess how the institutional arrangements map to key governance functions. The following analysis draws on the institutional inventory to identify strengths and gaps.

¶2 *Table 3.7.4: Governance dimension assessment — hypothetical Pacific SIDS*

Governance dimension	Assessment	Evidence from institutional inventory
Coverage	Moderate. The EEZ is formally covered by the Ministry of Fisheries and Maritime Authority mandates, but effective presence is limited by patrol capacity (2 patrol vessels for 1.2 million km²). Nearshore areas are well-covered through overlapping national and subnational mandates.	Institutions 1, 3, 6, 7 collectively cover all maritime zones; but see compliance assessment below
Coherence	Mixed. No integrated ocean policy or marine spatial plan currently exists. Fisheries and environment mandates overlap for coral reef areas, creating potential for conflicting regulatory decisions. The MPA Authority (est. 2019) coordinates with Ministry of Fisheries through a non-binding MOU.	Institutions 1 and 2 have overlapping jurisdiction in reef areas; Institution 6 coordinates via MOU only

Governance dimension	Assessment	Evidence from institutional inventory
Compliance	Low to moderate. The Fisheries Act requires vessel reporting, but compliance monitoring is constrained by limited VMS coverage (65% of licensed vessels) and infrequent patrols. Nearshore compliance is higher due to community-based monitoring by Island Councils and traditional governance systems.	Institutions 1, 7, 8 contribute to compliance; 2 patrol vessels cover 1.2M km²
Adaptiveness	Moderate. The Fisheries Act includes provisions for adaptive management (catch limits may be adjusted based on stock assessments), and the traditional rahui/tabu system provides flexible seasonal closures. However, formal review cycles for most legislation exceed 10 years.	Institutions 1 (adaptive provisions), 8 (traditional closures); legislative review cycles are long
Participation	Moderate to high. The Traditional Chiefs Council provides a formal channel for community participation in fisheries management (recognized under Fisheries Act s.45). Environmental impact assessment processes under the Environment Act require public consultation. However, participation in MPA designation has been inconsistent.	Institutions 2 (EIA consultation), 8 (traditional participation); Institution 6 (variable consultation record)

3.6.4 Governance coverage index calculation

¶1 A governance coverage index can be computed from the institutional inventory to assess the proportion of the accounting area covered by effective governance arrangements. This is an illustrative calculation, and as noted in Section 3.4, standardised methods for governance effectiveness measurement are still developing. Coverage scores are assigned based on an evidence checklist: see the anchor criteria below.

¶2 **Evidence checklist for coverage score assignment.** Coverage scores reflect the de facto governance capacity present in each zone, distinguishing de jure authority (formal mandate) from de facto implementation (Worldwide Governance Indicators framework, World Bank[44]). The following anchor criteria apply:

DRAFT

Score tier	Criterion
High (≥ 0.8)	Multiple institutions with documented operational presence; monitoring, control and surveillance (MCS) arrangements consistent with the FAO Voluntary Guidelines on Flag State Performance[45], including documented vessel monitoring system (VMS) coverage for the reference period; at least one enforcement report produced in the reference period; and community-based monitoring active
Moderate (0.5–0.79)	At least one institution with regular operational presence; MCS arrangements operational for the reference fleet segment; patrol or surveillance records available; partial VMS coverage documented
Low (< 0.5)	Formal mandate exists but documented operational presence is limited; no enforcement report available for the reference period; VMS or equivalent MCS documentation absent

¶3 **Spatial coverage calculation:**

Maritime zone	Area (km²)	Institutions with mandate	Effective governance assessment	Coverage score
Internal waters and lagoons	2,000	Institutions 5, 7, 8	High: multiple institutions with local presence, community-based monitoring, traditional governance, MCS arrangements active	0.9

Maritime zone	Area (km²)	Institutions with mandate	Effective governance assessment	Coverage score
Territorial sea (0–12 nm)	15,000	Institutions 1, 2, 3, 6	Moderate to high: regular patrols, MPA coverage (3 MPAs, 2,000 km²), environmental monitoring, VMS coverage documented	0.7
EEZ (12–200 nm)	1,183,000	Institutions 1, 3, 6, 9, 10	Low to moderate: MCS arrangements operational (VMS coverage for licensed fleet documented per reference period); 3 offshore MPAs (43,000 km²); limited patrol capacity	0.4

¶4 **Weighted governance coverage index:**

> *Coverage index = Sum(area x coverage score) / Total area*

> *= (2,000 x 0.9 + 15,000 x 0.7 + 1,183,000 x 0.4) / 1,200,000*

> *= (1,800 + 10,500 + 473,200) / 1,200,000*

> *= 485,500 / 1,200,000*

> *= 0.40*

DRAFT

¶5 **Sensitivity analysis.** The index result of 0.40 is sensitive to the score assigned to the EEZ, which dominates total area. Table 3.7.14 illustrates how the index changes under three score assumption scenarios for the EEZ zone:

¶6 *Table 3.7.14: Governance coverage index sensitivity analysis — EEZ score variation*

EEZ score assumption	Rationale	Index result
0.3 (pessimistic)	Limited patrol capacity and incomplete enforcement records	0.31
0.4 (base case)	MCS operational but coverage limited	0.40
0.5 (optimistic)	Full VMS coverage assumed; patrol capacity understated	0.50

¶7 The index is not sensitive to the internal waters or territorial sea score assumptions because these zones are small relative to the EEZ. Users should report the index result together with the underlying score assumptions and this sensitivity table.

3.6.5 Key observations from the worked example

¶1 This hypothetical example illustrates several important features of governance accounting:

1. ¶2
   Multi-level governance is the norm. Ten institutions operating at four levels (international, regional, national, community) share governance responsibilities. No single institution holds authority over all ocean management functions.
2. ¶3

Customary governance fills critical gaps. The Traditional Chiefs Council (Institution 8) provides governance functions (compliance monitoring, adaptive management through seasonal closures) in nearshore areas that would otherwise require significant government expenditure to replicate. Governance accounts should document these customary institutions alongside formal agencies, consistent with the guidance in **TG-3.6 Traditional Knowledge Accounts**.

3. ¶4
The governance coverage index is sensitive to spatial weighting. Because the EEZ dominates total marine area, the coverage index is heavily influenced by EEZ governance capacity. The choice of weighting scheme should be matched to the analytical purpose:

Analytical purpose	Recommended weighting
GBF/SDG spatial coverage indicators (e.g., Target 3, SDG 14.5.1)	Spatial area weighting (as in the base case above)
Revenue-at-risk and fisheries governance adequacy	Economic value weighting (e.g., by tuna licensing revenue per zone)
Equity and access analysis	Population-proximity weighting (e.g., by coastal population within 10 km of zone boundary)

Any published index figure must include a standardised metadata statement identifying the weighting scheme used. Inter-country comparison using the index is only valid where the same weighting scheme is applied consistently across countries.

4. ¶5
Coherence gaps are identifiable. The overlap between fisheries and environmental mandates in coral reef areas, and the absence of an integrated marine spatial plan, represent coherence gaps that governance accounts can document and track over time.

5. ¶6
Budget and staffing data provide a resource dimension. Total government expenditure on ocean governance in this example is approximately USD 12.9 million per year with 275 staff (FTE), or approximately USD 10.75 per km² of maritime area. This metric can be compared across countries and tracked over time to assess trends in governance investment. In the compiled COFOG expenditure table (Table 3.7.13), fisheries management and marine biodiversity protection together account for approximately half of total ocean governance expenditure, consistent with the country's economic priorities and conservation commitments.

DRAFT

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

FOOTNOTES

1. ¶1 United Nations, *United Nations Convention on the Law of the Sea* (UNCLOS), adopted 10 December 1982, entered into force 16 November 1994.
2. ¶2 UNCLOS Article 2: "The sovereignty of a coastal State extends, beyond its land territory and internal waters and, in the case of an archipelagic State, its archipelagic waters, to an adjacent belt of sea, described as the territorial sea."
3. ¶3 UNCLOS Article 56 establishes that in the EEZ, the coastal State has sovereign rights for exploring and exploiting, conserving and managing natural resources, and jurisdiction with regard to artificial islands, marine scientific research, and protection of the marine environment.
4. ¶4 United Nations, *Global indicator framework for the Sustainable Development Goals*, SDG indicator 14.2.1.
5. ¶5 UNCLOS Article 77: "The coastal State exercises over the continental shelf sovereign rights for the purpose of exploring it and exploiting its natural resources."
6. ¶6 UNCLOS Article 89: "No State may validly purport to subject any part of the high seas to its sovereignty." Article 87 establishes the freedoms of the high seas, including navigation, overflight, fishing, and scientific research.
7. ¶7 UNCLOS Article 137: "All rights in the resources of the Area are vested in mankind as a whole, on whose behalf the Authority shall act."

8. ¶8 UNCLOS Article 63 addresses stocks occurring within the EEZs of two or more coastal States or both within the EEZ and in areas beyond and adjacent to it.
9. ¶9 United Nations Statistics Division, *Classifications of Expenditure According to Purpose* (2000), COFOG classification structure.
0. ¶10 United Nations General Assembly, *United Nations Declaration on the Rights of Indigenous Peoples*, A/RES/61/295, adopted 13 September 2007.
1. ¶11 FAO. (2024). *Status and trends of SDG 14 indicators under FAO custodianship*. In *The State of World Fisheries and Aquaculture 2024*. FAO, Rome.
2. ¶12 FAO. (2015). *Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication*. FAO, Rome.
3. ¶13 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UN Fish Stocks Agreement), 1995.
4. ¶14 Convention on Biological Diversity, *Kunming-Montreal Global Biodiversity Framework* (2022), Target 3 on protected areas and OECMs.
5. ¶15 Convention on Biological Diversity, *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization* (Nagoya Protocol), adopted 29 October 2010, entered into force 12 October 2014.
6. ¶16 Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction (BBNJ Agreement), adopted 19 June 2023.
7. ¶17 WCPFC. (2023). *CMM 2023-04: Compliance Monitoring Scheme*. Western and Central Pacific Fisheries Commission, Kolonia.
8. ¶18 United Nations. (2025). *System of National Accounts 2025*. UN Statistics Division. United Nations. (2021). *System of Environmental-Economic Accounting—Ecosystem Accounting*. UN Statistics Division.
9. ¶19 United Nations, *Global indicator framework for the Sustainable Development Goals*, SDG indicator 14.c.1.
0. ¶20 IUCN, *Guidelines for Applying Protected Area Management Categories* (2008). This definition is also referenced in SEEA Central Framework discussions of protected areas.
1. ¶21 Hockings, M., Stolton, S., Dudley, N., and Leverington, F. (2020). *METT-4: A guide to using the Management Effectiveness Tracking Tool (METT-4)*. WWF / World Bank, Washington, DC.
2. ¶22 IUCN WCPA. (2018). *Green List of Protected and Conserved Areas: Standard, Version 1.1*. IUCN, Gland, Switzerland.
3. ¶23 CBD. (2022). *Decision 15/5: Monitoring framework for the Kunming-Montreal Global Biodiversity Framework*. Convention on Biological Diversity, Montreal.
4. ¶24 UNCLOS Article 62(4) specifies that laws and regulations for fishing in the EEZ may relate to licensing, determining species, regulating seasons and areas, specifying information requirements, and other matters.
5. ¶25 United Nations, *Global indicator framework for the Sustainable Development Goals*, SDG indicator 14.b.1. This indicator measures frameworks that recognise and protect access rights for small-scale fisheries.
6. ¶26 United Nations et al., *System of Environmental-Economic Accounting—Central Framework* (SEEA CF, 2012), Chapter 4 on environmental transactions; Chapter 5 on environmental asset accounts.
7. ¶27 OECD. (2025). *Measuring Natural Resources in the National Accounts: A Compilation Guide*. OECD Publishing, Paris.
8. ¶28 FAO. (2020). *System of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries (SEEA AFF)*. FAO, Rome.
9. ¶29 SDG Target 14.6: "By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies."
0. ¶30 FAO. *Guide for identifying, assessing and reporting on subsidies in the fisheries sector*. FAO, Rome. See also the WTO Agreement on Fisheries Subsidies (adopted 2022, in force 2024) for the international framework on capacity-enhancing subsidies.
1. ¶31 FAO. *FishStatJ: Software for Fishery and Aquaculture Statistical Time Series*. FAO, Rome. Available at: https://www.fao.org/fishery/statistics/software/fishstatj/en (https://www.fao.org/fishery/statistics/software/fishstatj/en)
2. ¶32 United Nations Statistics Division, *Classifications of Expenditure According to Purpose* (2000), COFOG paras. 15—31 on classification structure and paras. 19, 22 on apportionment of multi-function agencies and identification of environmental protection expenditures.
3. ¶33 World Tourism Organization & United Nations Statistics Division (2024). *Statistical Framework for Measuring the Sustainability of Tourism*, Table 3.9, "Tourism related Functions of Government — COFOG classes", and paras 2.30—2.31 on the ratio methodology and its documentation requirements. The ocean-share approach in Table 3.7.7 adapts that method.
4. ¶34 The sequence follows the SNA distinction between rent (payments for the use of a natural resource owned by another institutional unit, recorded as property income), sales of services (payments for which a commensurate service is received), and taxes (compulsory unrequited transfers to government), together with the SEEA CF definition of environmental taxes by tax base. Compilers should verify paragraph references against the SNA and SEEA editions in use, since numbering differs between editions and the SNA 2025 treatment of permits and licences is presented differently from SNA 2008.

DRAFT

5. ¶35 United Nations et al., *System of Environmental-Economic Accounting—Central Framework* (SEEA CF, 2012), paras. 4.148—4.155 on environmental taxes. Environmental taxes are classified by tax base (energy, transport, pollution, resources) rather than stated purpose.
6. ¶36 See *SEEA Central Framework* Chapter 5 on the valuation of environmental assets and the role of resource rent, and the depletion and resource rent procedure at TG-1.1 Section 3.4.
7. ¶37 UNEP-WCMC. *World Database on Protected Areas (WDPA) data standard*. UNEP-WCMC, Cambridge.
8. ¶38 SDG Target 16.6: "Develop effective, accountable and transparent institutions at all levels."
9. ¶39 United Nations, *Global indicator framework for the Sustainable Development Goals*, SDG indicator 16.7.2.
0. ¶40 IUCN, *IUCN Green List of Protected and Conserved Areas: Standard, Version 1.1* (2018).
1. ¶41 United Nations, *Global indicator framework for the Sustainable Development Goals*, SDG indicators 14.5.1 and 14.2.1.
2. ¶42 United Nations. (2025). *System of National Accounts 2025*, Chapter 13 — Balance Sheets. UN Statistics Division.
3. ¶43 Budget figures are hypothetical. The USD 12.9M total is derived from institutional budget totals of USD 13.4M after removing USD 0.5M in double-counted regional contributions (FFA and WCPFC), as detailed in the reconciliation bridge in Section 3.6.2.
4. ¶44 World Bank. *Worldwide Governance Indicators — Methodology and Analytical Issues*. World Bank, Washington, DC.
5. ¶45 FAO. (2014). *Voluntary Guidelines for Flag State Performance*. FAO, Rome.

DRAFT

Combined Presentations

Creates combined presentations that integrate physical, monetary, and qualitative accounts for ocean accounting, drawing on asset accounts (TG-3.1).

Version 0.9.3 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

OUTCOME

After completing this Circular, readers will be able to create combined presentations that integrate physical, monetary, and qualitative accounts for ocean accounting, drawing on asset accounts (TG-3.1), flow accounts (TG-3.2, TG-3.4), economic activity accounts (TG-3.3), social accounts (TG-3.5), and governance accounts (TG-3.7). Combined presentations are an analytical layer, not new accounts; they enable decision-makers to understand connections between ecosystem condition, economic activity, and human wellbeing. Key use cases include ocean management dashboards, parliament reporting on ocean wealth, SDG 14 progress tracking, and marine spatial planning. Section 3.1 covers combination principles; Sections 3.2–3.3 address physical-monetary and social-governance integration; Sections 3.4–3.5 cover compilation and communication; Sections 3.6–3.11 address extended balance sheets, the dashboard specification, cross-domain integration, sub-national presentations, and a worked example.

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 4
3.1 Integrated Ocean Account Framework 5
3.2 Physical-Monetary Integration 7
3.3 Including Social and Governance Dimensions 9
3.4 Compilation Procedure for Combined Presentations 10
3.5 Visualization and Communication 13
3.6 Extended Balance Sheets 15
3.7 Integrated Ocean Dashboard Specification 16
3.8 Cross-Domain Integration Protocol 18
3.9 Sub-National Combined Presentations 21
3.10 Worked Example: Integrated Coastal Zone Combined Presentation 23
3.11 Condition-to-Services Data-Flow Integration 28
4. Summary 28
Implementation Considerations 29
5. Acknowledgements 29
6. References 29

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Combined Presentations (2026) (GOAP Technical Guidance on Ocean Accounting, TG-3.8, v0.9.3). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-3/3-8-combined-presentations/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

1. Outcome

¶1 After completing this Circular, readers will be able to create combined presentations that integrate physical, monetary, and qualitative accounts for ocean accounting, drawing on asset accounts (**TG-3.1**), flow accounts (**TG-3.2**, **TG-3.4**), economic activity accounts (**TG-3.3**), social accounts (**TG-3.5**), and governance accounts (**TG-3.7**). Combined presentations are an analytical layer, not new accounts; they enable decision-makers to understand connections between ecosystem condition, economic activity, and human wellbeing. Key use cases include ocean management dashboards, parliament reporting on ocean wealth, SDG 14 progress tracking, and marine spatial planning. Section 3.1 covers combination principles; Sections 3.2–3.3 address physical-monetary and social-governance integration; Sections 3.4–3.5 cover compilation and communication; Sections 3.6–3.11 address extended balance sheets, the dashboard specification, cross-domain integration, sub-national presentations, and a worked example[1].

2. Requirements

¶1 **Essential prerequisites:**

- ¶2 **TG-0.1 General Introduction to Ocean Accounts**: conceptual framework and key components of Ocean Accounts
- ¶3 **TG-3.1 Asset Accounts**: methodology of physical and monetary asset accounts

¶4 **Helpful background:**

- ¶5 **TG-0.2 Overview of Relevant Statistical Standards**: classification frameworks and international statistical standards
- ¶6 **TG-3.2 Flows Environment to Economy**: physical flow accounting of natural resource extraction and ecosystem service use
- ¶7 **TG-3.3 Economic Activity Relevant to the Ocean**: ocean economy thematic and extended accounting framework
- ¶8 **TG-3.4 Flows Economy to Environment**: residual flow accounts documenting pressures on the marine environment

¶9 ⓘ **Framework Position**

¶10 This Circular addresses the integration of all component accounts into coherent presentations. Combined presentations draw on all eleven accounting relationships (E1–E11) identified in the Ocean Accounts Framework, assembling data from asset accounts, flow accounts, social accounts, and governance accounts into thematic views that support decision-making. In the Ocean Accounts Framework (TG-0.1 Figure 0.1.2):

Edge	Direction	Description
Scope. TG-3.8 owns the combined presentation: how accounts already compiled elsewhere are assembled into one coherent view, the consistency conditions that assembly requires, and the dashboard and integrated-table formats. It compiles no account of its own, and it cross-refers to the circular that owns each component account rather than restating its method.		

¶11 | E1 | FG1 → SG3 | Pollution/residuals from economy to environment | | E2 | FG2 → SG3 | Pollution/residuals from society to environment | | E3 | FG1 ↔ SG1 | Monetary flows between assets and economic sectors | | E4 | FG2 ↔ SG1 | Social activities interacting with SNA assets | | E5 | FG1 → SG2 | Economic contributions to social conditions | | E6 | FG2 → SG2 | Social activities to social conditions | | E7 | SG2 → FG1 | Social assets enabling economic flows | | E8 | SG2 → FG2 | Social assets enabling social activities | | E9 | SG3 → FG1 | Ecosystem services to economy | | E10 | SG3 → FG2 | Ecosystem services to society | | E11 | FG3 ↔ SG3 | Intermediate ecosystem services |

DRAFT

3. Guidance Material

¶1 The SEEA Ecosystem Accounting framework recognises that policy and analysis related to the environment and human connection to it can be framed in many ways, often requiring consideration of specific environmental themes such as biodiversity, climate change, oceans, and urban areas [2]. The ocean accounts framework responds to this need by integrating data from the SEEA Central Framework, SEEA Ecosystem Accounting, and the System of National Accounts into a coherent information set that supports decision-making for ocean governance.

¶2 Combined presentations enable decision-makers to monitor several trends: changes in ocean ecosystem extent and condition; changes in ocean wealth including produced and non-produced assets; ocean-related income and welfare for different groups of people; ocean-based economic production; and changes in how oceans are governed and managed [3]. These feed a range of ocean governance processes including marine spatial planning, integrated coastal zone management, development planning for ocean sectors, and collaborative resource management.

¶3 The Global Ocean Accounts Partnership (GOAP) develops and promotes the ocean accounts framework internationally. The SEEA EA recognises the existence of an "ocean accounting community of practice" whose objective is to ensure that data common to multiple communities—including those for marine spatial planning, disaster risk, and climate change—are standardised and shared [4]. The GOAP has supported pilot studies in several countries (see Section 3.2) and continues to advance methodological guidance for implementing combined presentations.

¶4 The general ecosystem accounting framework illustrated in Figure 3.8.1[5] provides the conceptual foundation for combined presentations. It shows how ecosystem assets are measured through extent, condition, and other characteristics, how they supply ecosystem services, and how those services flow to the economy, generating benefits for society.

DRAFT

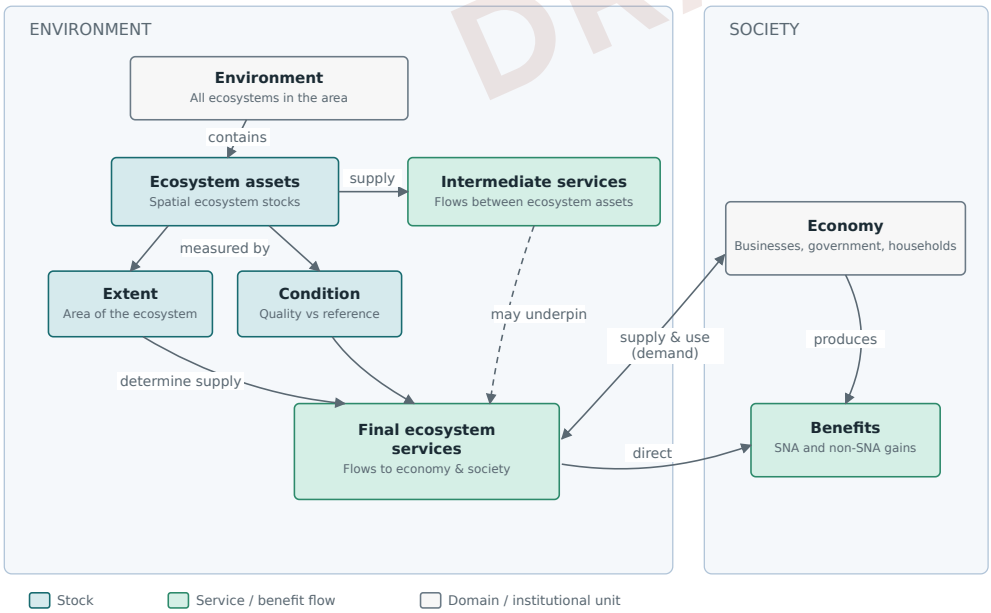


Figure 3.8.1 Ecosystem assets measured by extent and condition supply final ecosystem services to the economy and society. Intermediate services stay within the Environment. Nodes coloured by stock, flow, or institutional domain; economy nested within society.

3.1 Integrated Ocean Account Framework

Structure and components

¶1 The ocean accounts framework builds on SEEA EA ecosystem extent, ecosystem condition, and ecosystem services flow accounts, adding accounts for natural resources and physical flows from the SEEA Central Framework and accounts for the ocean economy, governance, management, and technology[6]. Figure 3.8.2 illustrates the coverage of this integrated framework.

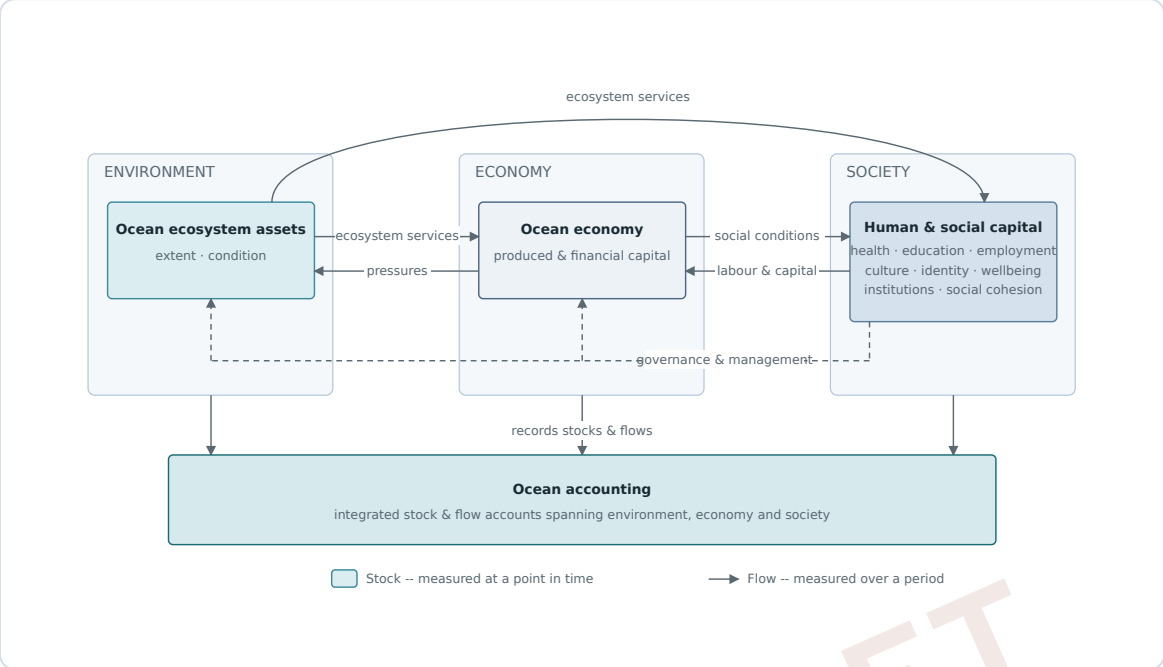


Figure 3.8.2 Ocean accounting integrates environment, economy, and society pillars as linked capital stocks and flows. Flows include ecosystem services, labour and capital, pressures returning to the environment, and governance responses.

DRAFT

¶2 The core components of an integrated ocean account framework are:

¶3 **Environmental accounts** comprise the physical and monetary measurement of ocean-related environmental assets and flows:

- ¶4 Extent accounts for coastal and marine ecosystem types (see **TG-3.1 Asset Accounts**)
- ¶5 Condition accounts recording ecosystem health indicators (see **TG-2.1 Aggregate Biophysical Indicators of Environmental State**)
- ¶6 Ecosystem services flow accounts in physical and monetary terms (see **TG-2.4 Ecosystem Goods and Services**)
- ¶7 Individual environmental asset accounts for fish stocks, minerals, and energy resources
- ¶8 Physical flow accounts for pressures including emissions and waste (see **TG-3.4 Flows Economy to Environment**)

¶9 **Economic accounts** document the contribution of the ocean to economic activity:

- ¶10 Ocean economy thematic and extended accounts measuring industry contributions to GDP (see **TG-3.3 Economic Activity Relevant to the Ocean**)
- ¶11 Supply and use tables for ocean-characteristic products
- ¶12 Employment accounts for ocean-related industries
- ¶13 Investment accounts for ocean infrastructure (see **TG-2.6 Ocean Investment**)

¶14 **Social accounts** record human dimensions of ocean-society relationships:

- ¶15 Wellbeing indicators for ocean-dependent communities (see **TG-3.5 Social Accounts**)
- ¶16 Equity measures showing distribution of benefits and burdens
- ¶17 Vulnerability and resilience indicators
- ¶18 Traditional knowledge and cultural connections (see **TG-3.6 Traditional Knowledge**)

¶19 **Governance accounts** document institutional arrangements:

- ¶20 Marine spatial planning coverage and zoning
- ¶21 Regulatory frameworks and compliance
- ¶22 Management effectiveness indicators (see **TG-3.7 Governance Accounts**)

Principles for combining accounts

¶1 The SEEA EA identifies three key principles that enable accounts for different themes to be combined into coherent presentations [7]:

¶2 **First**, there must be a clearly agreed geographical area. For ocean accounting, this is the ocean accounting area, which typically aligns with a country's Exclusive Economic Zone (EEZ) plus territorial waters and coastal zones. For thematic presentations, a focus on more targeted areas (e.g., specific catchments, marine protected areas, or ecosystem types) may be appropriate. The delineation of geographical areas should follow the guidance in **TG-0.1 General Introduction to Ocean Accounts** regarding the ocean accounting area.

¶3 **Second**, there must be a set of entities that are the focus of accounting. In ecosystem accounting, the focus is on ecosystems; in the SNA, the focus is on economic units; in the Central Framework, the focus is on individual stocks and flows. Combined presentations integrate multiple entity types, requiring consistent classifications that allow linkages across domains. The classification frameworks described in **TG-0.2 Overview of Relevant Statistical Standards** provide the basis for this consistency.

¶4 **Third**, multiple accounts are required to organise relevant information for a single theme. The SEEA and SNA frameworks demonstrate that no single account captures all relevant information. The same applies to combined presentations: a coherent narrative for ocean sustainability requires extent accounts, condition accounts, service flow accounts, economic accounts, and potentially social and governance accounts.

¶5 Links between accounts are possible because of consistent application of a delineated geographical boundary and consistent classifications for agreed entities [8]. This allows combined presentations to convey a coherent narrative, support derivation of consistent indicators, and enable integration of data into models and analytical tools.

¶6 Accounting principles are equally applicable across different spatial scales and entities [9]. Combined presentations can therefore operate at national, regional, or local scales depending on the policy question being addressed. The SEEA EA notes that choices of geographical area, entity types, and classifications "should be made with a focus on the use of the accounts, including the potential to compare results over time and in different locations" [9]. For ocean accounting, this means that combined presentations for marine spatial planning may operate at local scales (individual bays, reefs, or marine management areas), whilst those supporting national development planning may aggregate to the full EEZ. Compilers should align the spatial scope of combined presentations with existing administrative boundaries and decision-making processes, following the broader guidance in SEEA EA para. 13.9 on linking geographical scope to existing data and governance arrangements.

¶7 The connections between the core ecosystem accounts that underpin combined presentations are illustrated in Figure 3.8.3 [10]. Ecosystem extent and condition accounts are mutually informing; condition data feeds into physical ecosystem service flow accounts; physical and monetary service

DRAFT

flow accounts are linked through valuation; and monetary service flows provide the basis for monetary ecosystem asset valuation.

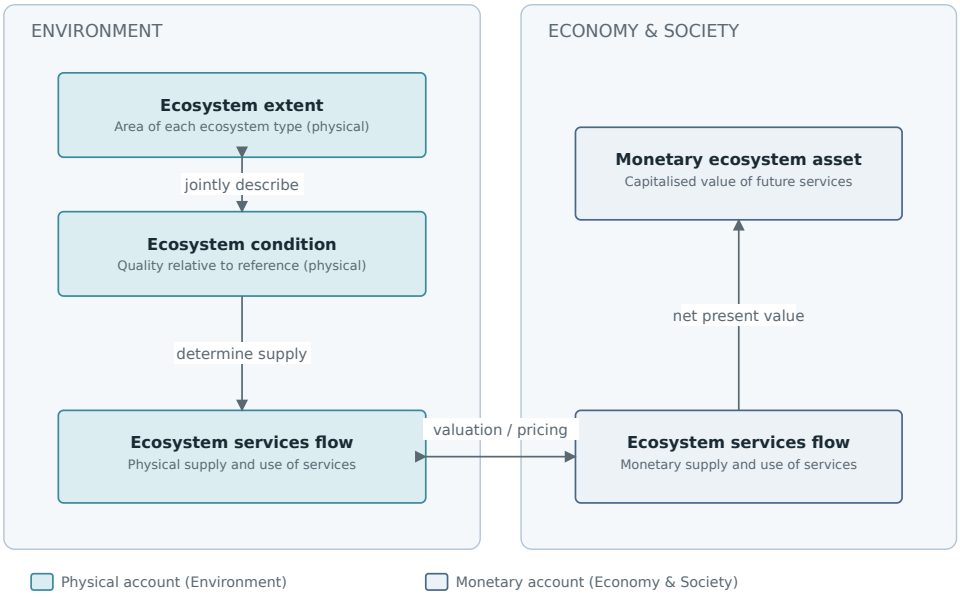


Figure 3.8.3 Five SEEA EA ecosystem accounts connect: extent and condition determine physical service flows that value into monetary accounts. Physical flows link by valuation to monetary service flows, which accumulate as NPV into the monetary asset account.

DRAFT

3.2 Physical-Monetary Integration

¶1 A distinctive feature of combined presentations is the integration of physical and monetary data to provide complementary perspectives on ocean resources. Physical accounts record stocks and flows in tonnes, hectares, cubic metres, or number of individuals; monetary accounts translate these into currency values that can be aggregated and compared with economic aggregates[11].

Approaches to integration

¶1 Three approaches to physical-monetary integration are relevant for ocean accounting:

¶2 **Parallel presentation** displays physical and monetary accounts side by side, allowing users to examine both dimensions. This approach is particularly useful when physical quantities and monetary values diverge—for example, when the monetary value of a fish stock increases due to rising prices even as physical biomass declines. Parallel presentation preserves information in both dimensions without implying that one takes precedence. The asset account structure in **TG-3.1 Asset Accounts** provides the foundation for parallel presentation of physical and monetary data.

¶3 **Hybrid accounts** integrate physical and monetary data within a single table structure. The SEEA Central Framework describes hybrid accounts for environmental protection expenditure that show both monetary expenditure and associated physical outcomes (e.g., tonnes of pollutants removed)[12]. For ocean accounting, hybrid accounts might show investment in coastal protection infrastructure alongside physical measures of coastal erosion or protection.

¶4 **Extended supply and use tables** incorporate physical flows alongside monetary transactions. The SEEA EA describes how physical supply and use tables for ecosystem services can be linked to

monetary supply and use tables, enabling analysis of the physical basis of economic activity[13]. For the ocean economy, this approach reveals the material throughput underlying economic output. The supply and use framework in **TG-3.3 Economic Activity Relevant to the Ocean** provides the basis for this integration.

Linking ecosystem services to economic activity

¶1 Linking ecosystem services from marine ecosystems to economic activity is a central integration task. The SEEA EA framework provides the conceptual basis: ecosystem services represent the contributions of ecosystems to benefits, with ecosystem services flow accounts recording the supply by ecosystem types and the use by economic units and households[14].

¶2 For combined presentations, the linkage can be illustrated by tracing provisioning services through to economic output, as summarised in Table 3.2.1 below.

Step	Account and contribution
1. Ecosystem extent and condition accounts	(see **TG-3.1 Asset Accounts**) record the area and health of fish-supporting ecosystems.
2. Ecosystem services accounts	(see **TG-2.4 Ecosystem Goods and Services**) record the biomass provisioning service — fish available for harvest.
3. Individual asset accounts	(see **TG-3.1 Asset Accounts**, Section 3.3) record fish stock levels and sustainable yield.
4. Physical flow accounts	(see **TG-3.2 Flows Environment to Economy**) record the harvest (extraction from the environment).
5. Economic activity accounts	(see **TG-3.3 Economic Activity Relevant to the Ocean**) record the value added by the fishing industry.
6. Social accounts	(see **TG-3.5 Social Accounts**) record employment, income, and wellbeing for fishing-dependent communities.

DRAFT

¶3 This sequence illustrates how combined presentations trace the pathway from ecosystem assets through ecosystem services to economic activity and social outcomes.

Pilot implementation experience

¶1 The ocean accounts framework has supported pilot studies across several countries, each answering policy-relevant questions through combined presentations[15]. The pilot studies in Samoa, Thailand, and Viet Nam centred on sustainable tourism, linking tourism income, natural resource use, land-based pollution, and ecosystem impacts. China's pilot developed harmonised mangrove maps and improved understanding of environmental assets in Beihai Bay. Malaysia examined food security risk concerning fish stocks along the Straits of Malacca under expected future climate variability. All pilots depended on available data that were often limited, but one function of the ocean accounts framework was to guide the search for and integration of data[15].

¶2 These experiences demonstrate that combined presentations can be compiled even with partial data coverage. Compilers should begin with available accounts and progressively expand coverage as data systems mature, following the incremental implementation approach described in **TG-0.1 General Introduction to Ocean Accounts**.

Physical-monetary discrepancies

¶1 Combined presentations should explicitly address discrepancies between physical and monetary trends, as these often reveal important information for policy. Common discrepancies include:

- ¶2 **Declining physical stocks with stable or increasing values**: Rising scarcity can increase unit prices faster than stocks decline, masking physical depletion in monetary terms. This is particularly relevant for fisheries where declining catch per unit effort (CPUE) may coincide with increasing fish prices[16].
- ¶3 **Increasing physical stocks with declining values**: Abundance can reduce unit prices, potentially reducing incentives for sustainable management
- ¶4 **Unvalued ecosystem services**: Many regulating and cultural services from marine ecosystems are not captured in monetary accounts, creating gaps between fuller physical measures and partial monetary values. The treatment of ecosystem services valuation in **TG-1.9 Safe Usage of Monetary Valuation** addresses these measurement challenges.

¶5 The SEEA EA notes that "monetary values may be a poor guide to physical sustainability" and recommends that combined presentations include both physical and monetary information[17].

3.3 Including Social and Governance Dimensions

¶1 Combined presentations for ocean accounting extend beyond environmental and economic data to incorporate social and governance dimensions, following the full scope of the ocean accounts framework.

Social dimensions

¶1 The 2025 SNA recognises that national accounts contribute to measuring wellbeing and sustainability beyond GDP, including through extended accounts for labour, human capital, and household distributional analysis[18]. For ocean accounting, social dimensions include:

¶2 **Distributional analysis** examines how the benefits and costs of ocean use are distributed across population groups. Combined presentations can show, for example:

- ¶3 How ocean economy employment is distributed by region, gender, and age group (see **TG-3.5 Social Accounts**, Section 3.6.2)
- ¶4 How coastal ecosystem degradation disproportionately affects vulnerable communities (see **TG-3.5 Social Accounts**, Section 3.3)
- ¶5 How access to marine recreation varies across income groups

¶6 **Wellbeing indicators** complement monetary measures with broader dimensions of quality of life. The social accounts guidance in **TG-3.5 Social Accounts** identifies relevant domains including employment quality, food security, health, and cultural connections to the ocean.

¶7 **Vulnerability and resilience** measures document the susceptibility of communities to ocean-related shocks and their capacity to adapt. Combined presentations can integrate data on:

- ¶8 Economic dependence on ocean sectors
- ¶9 Exposure to environmental pressures and pollution (see **TG-2.7 Pollution and Other Flows to Environment**)
- ¶10 Adaptive capacity indicators

Governance dimensions

¶1 Governance accounts document the institutional arrangements that shape ocean use and management (see **TG-3.7 Governance Accounts**). For combined presentations, governance data provides context for interpreting environmental and economic trends:

¶2 **Marine spatial planning** accounts show the allocation of ocean space across different uses, enabling analysis of how spatial planning decisions relate to ecosystem condition and economic outcomes.

¶3 **Protected area coverage** accounts document the extent of marine protected areas and other area-based conservation measures, which can be related to ecosystem condition and

DRAFT

ecosystem service flows. SDG indicator 14.5.1 measures "Coverage of protected areas in relation to marine areas" [19].

¶4 **Management effectiveness** indicators assess whether governance arrangements are achieving their objectives, providing context for understanding why environmental or economic outcomes are improving or declining.

¶5 The SEEA EA describes governance accounts as including "explicit consideration of institutional and legal frameworks such as zoning, rules and decision-making institutions, social circumstances of affected populations, and measures of ocean-related risks and resilience to them" [20].

3.4 Compilation Procedure for Combined Presentations

¶1 This procedure assumes that the underlying component accounts have already been compiled following the guidance in the relevant circulars (TG-3.1 through TG-3.7). The steps below address the additional work needed to combine those accounts into an integrated presentation.

Step 1: Define the policy question and presentation scope

¶1 The compilation process begins with defining the policy question the combined presentation will address. This determines which accounts to include, the geographical scope, and the temporal frame. SEEA CF para. 6.56 emphasises that "the structures of combined presentations of monetary and physical data are dependent on the availability of data and the question under investigation" [21].

¶2 For ocean accounting, typical policy questions include:

- ¶3 Is the ocean economy growing sustainably? (requires asset accounts, economic accounts, and depletion measures)
- ¶4 How do coastal protection benefits from ecosystems compare to infrastructure costs? (requires ecosystem service accounts, ecosystem extent/condition accounts, and public expenditure accounts)
- ¶5 Are fishing communities benefiting from improved fish stock management? (requires fish stock asset accounts, economic accounts for fisheries, and social accounts for fishing-dependent communities)

¶6 Once the policy question is defined, compilers should document:

- ¶7 The specific policy decision or analytical purpose the presentation will serve
- ¶8 The primary users (cabinet, parliament, planning ministry, coastal management agency)
- ¶9 The geographical scope (national EEZ, specific coastal zone, marine protected area)
- ¶10 The time period and frequency (annual snapshots, multi-year trends)
- ¶11 Which accounts are essential versus desirable for answering the question

Step 2: Identify and assemble component accounts

¶1 Based on the defined scope, compilers identify the component accounts required and assess their availability and quality. Component accounts may include:

¶2 **Core accounts** (always required):

- ¶3 Ecosystem extent accounts for relevant marine/coastal ecosystem types
- ¶4 Economic accounts showing ocean economy GVA and employment
- ¶5 At least one flow account (either environment-to-economy or economy-to-environment)

¶6 **Supporting accounts** (included as available):

- ¶7 Ecosystem condition accounts
- ¶8 Ecosystem services flow accounts (physical and monetary)
- ¶9 Fish stock or other individual environmental asset accounts
- ¶10 Social accounts (employment, distributional measures)

DRAFT

- ¶11 Governance accounts (protected areas, zoning)
- ¶12 Public expenditure accounts for ocean-related functions

¶13 For each identified account, compilers should verify:

- ¶14 Reference period (does it match the presentation timeframe?)
- ¶15 Geographical coverage (does it align with the defined accounting area?)
- ¶16 Classification systems (are they consistent with other accounts?)
- ¶17 Data quality ratings and limitations
- ¶18 Update frequency and publication lag

Step 3: Reconcile classifications and boundaries

¶1 Before combining accounts, compilers must ensure consistent classifications and boundary definitions. The SEEA CF notes that "any differences in classification need to be resolved before physical and monetary data are combined" (para. 6.88)[22].

¶2 Key reconciliation tasks include:

¶3 **Geographical boundaries**: Verify that all accounts refer to the same ocean accounting area. Where accounts use different spatial units (e.g., administrative regions versus ecosystem spatial units), establish concordance tables or spatial overlays to enable consistent aggregation.

¶4 **Time periods**: Align all accounts to a common reference period. The SEEA CF emphasises that "it is important to ensure that the source data underpinning the physical and the monetary data relate to the same accounting period" (para. 6.71)[23]. Where accounts use different reference dates (e.g., fiscal year versus calendar year, or biological stock assessment periods versus accounting years), document the adjustments made.

¶5 **Product and industry classifications**: Ensure that ocean economy accounts, supply-use tables, and physical flow accounts use consistent classifications. Map national classifications to ISIC (industries) and CPC (products) as described in **TG-0.2 Overview of Relevant Statistical Standards**.

¶6 **Ecosystem type classifications**: Confirm that extent accounts, condition accounts, and ecosystem service accounts use the same ecosystem type classification, typically based on the IUCN Global Ecosystem Typology for marine biomes.

¶7 **Measurement units**: Standardise physical units across accounts. For example, ensure fish biomass is consistently measured in tonnes (live weight), ecosystem extent in square kilometres, and carbon flows in tonnes CO2-equivalent.

Step 4: Structure the presentation format

¶1 With component accounts identified and classifications reconciled, compilers design the presentation format. The SEEA CF describes a general structure (Table 6.4) that can be adapted for ocean themes, comprising four sections[24]:

¶2 **Section A: Monetary flows**

- ¶3 Supply and use of ocean-characteristic products (by industry and product)
- ¶4 Gross value added by ocean-related industries
- ¶5 Depletion-adjusted value added
- ¶6 Environmental taxes, subsidies, and transfers

¶7 **Section B: Physical flows**

- ¶8 Natural resource inputs (fish harvest, mineral extraction, water abstraction)
- ¶9 Ecosystem service flows (provisioning, regulating, cultural services by ecosystem type)
- ¶10 Residual flows (emissions, waste to marine environment)

¶11 **Section C: Stocks and asset flows**

DRAFT

- ¶12 Closing stocks of environmental assets (fish stocks, ecosystem extent, mineral reserves) in physical and monetary terms
- ¶13 Depletion and degradation
- ¶14 Closing stocks of fixed assets (vessels, offshore infrastructure, port facilities)
- ¶15 Gross fixed capital formation

¶16 **Section D: Related indicators**

- ¶17 Employment by ocean industry
- ¶18 Population in coastal zones
- ¶19 Productivity indicators (GVA per employee, resource productivity)
- ¶20 Intensity indicators (emissions per unit output, extraction per unit stock)

¶21 The column structure should remain consistent across all four sections to facilitate comparison. Typical column headings include:

- ¶22 Industries (by ISIC division or aggregation)
- ¶23 Households
- ¶24 Government
- ¶25 Capital accumulation
- ¶26 Rest of world
- ¶27 Total

Step 5: Populate the presentation and check accounting identities

¶1 With the structure defined, compilers populate the combined presentation by extracting relevant entries from component accounts. The SEEA CF stresses that accounting identities must be maintained: "it is important to ensure that the implicit relationships between quantities and prices are meaningful and reasonable" (para. 6.91)[25].

¶2 Key accounting identities to verify:

- ¶3 **Supply equals use**: For each product in monetary terms and each physical flow, total supply must equal total use
- ¶4 **Stock-flow consistency**: Changes in asset stocks (closing stock minus opening stock) must equal net additions (total additions minus total reductions)
- ¶5 **Physical-monetary consistency**: For marketed flows, the ratio of monetary value to physical quantity must yield plausible unit prices
- ¶6 **GVA aggregation**: Sum of GVA across ocean industries must equal ocean economy GVA reported in economic accounts

¶7 Where discrepancies arise, compilers should investigate whether they result from:

- ¶8 Differences in scope between accounts (e.g., residence versus territory recording)
- ¶9 Timing mismatches (e.g., production versus consumption timing)
- ¶10 Genuine data errors requiring correction in source accounts
- ¶11 Conceptual differences requiring explanatory notes

Step 6: Add contextual information and interpretation

¶1 The final step is adding contextual information that helps users interpret the combined presentation. The SEEA CF notes that combined presentations "have the potential to serve as a bridge between" scientists and economists (para. 6.59)[26], requiring clear communication for diverse audiences.

¶2 Essential contextual elements include:

DRAFT

- ¶3 **Introduction**: Brief statement of the policy question addressed and how the presentation supports decision-making
- ¶4 **Methodological notes**: Description of scope, classifications, valuation methods, data sources, and quality limitations
- ¶5 **Interpretation guidance**: Explanation of key patterns, trends, and discrepancies visible in the data
- ¶6 **Policy implications**: Summary of what the integrated data reveal about sustainability, distribution, or governance effectiveness
- ¶7 **References and links**: Citations to underlying accounts and related circulars

¶8 For multi-period presentations showing trends, additional contextual information should cover:

- ¶9 Changes in methodology or coverage affecting time-series comparability
- ¶10 Revisions made to earlier periods
- ¶11 Factors explaining observed trends (policy changes, external shocks, data improvements)

3.5 Visualization and Communication

Dashboard approaches

¶1 Dashboards provide a compact format for presenting key indicators drawn from combined accounts. The SEEA Central Framework describes combined presentations that bring together information from various accounts to support decision-making [27]. For ocean accounting, effective dashboards typically include:

¶2 **Headline indicators** that summarise overall status:

- ¶3 Total extent of marine and coastal ecosystems (from extent accounts)
- ¶4 Aggregate ecosystem condition index (see **TG-2.1 Aggregate Biophysical Indicators of Environmental State**)
- ¶5 Ocean economy contribution to GDP (see **TG-3.3 Economic Activity Relevant to the Ocean**)
- ¶6 Ocean-dependent employment (see **TG-3.5 Social Accounts**)

¶7 **Trend indicators** that show change over time:

- ¶8 Change in ecosystem extent by type
- ¶9 Change in condition for key ecosystem types
- ¶10 Change in sustainable yield versus actual harvest (see **TG-2.11 Resource Efficiency Indicators**)
- ¶11 Change in ocean economy employment

¶12 **Distributional indicators** that reveal how benefits and impacts are distributed:

- ¶13 Ecosystem services by beneficiary type (see **TG-2.4 Ecosystem Goods and Services**)
- ¶14 Economic benefits by region and community type
- ¶15 Vulnerability indicators by population group

¶16 **Pressure and response indicators** that show drivers and policy actions:

- ¶17 Pollution loads by source (see **TG-3.4 Flows Economy to Environment**)
- ¶18 Climate change impacts
- ¶19 Protected area coverage
- ¶20 Environmental expenditure

¶21 Table 1 provides an illustrative indicator template organised by account domain, drawing on indicator categories derived from ocean accounts [28]. Compilers should adapt this template to national circumstances and priority policy questions.

DRAFT

¶22 **Table 1: Illustrative Ocean Accounts Dashboard Indicator Template**

Domain	Indicator	Account Source	SDG Linkage
Ecosystem extent	Total area of marine and coastal ecosystems (km²)	Extent account	14.2.1
Ecosystem condition	Aggregate condition index by ecosystem type	Condition account	14.1.1
Ecosystem services	Value of provisioning services (fisheries, aquaculture)	Ecosystem services flow account	14.7.1
Ocean economy	Ocean economy GVA as share of national GDP	Thematic economic account	14.7.1
Employment	Ocean-dependent employment by sector and gender	Economic activity account	8.5.2
Pressures	Nutrient and pollution loads to marine waters (tonnes)	Residual flow account	14.1.1
Governance	Proportion of EEZ under marine spatial planning	Governance account	14.5.1
Ocean wealth	Change in total ocean natural capital (monetary)	Extended balance sheet	–

Indicator derivation

¶1 Combined presentations support derivation of indicators that span multiple account types. Examples relevant to ocean accounting include:

¶2 **Efficiency indicators** that relate economic output to environmental inputs:

- ¶3 Gross value added per tonne of fish harvested
- ¶4 Employment per hectare of aquaculture
- ¶5 Carbon emissions per unit of maritime transport output (see **TG-2.11 Resource Efficiency**)

¶6 **Sustainability indicators** that relate extraction to regeneration:

- ¶7 Harvest as a percentage of sustainable yield (see **TG-2.11 Resource Efficiency Indicators**)
- ¶8 Ecosystem degradation as a share of ecosystem service value
- ¶9 Depletion as a share of ocean economy value added

¶10 **Intensity indicators** that express environmental impacts relative to economic scale:

- ¶11 Pollution intensity of ocean industries
- ¶12 Land/ocean use intensity of coastal tourism
- ¶13 Resource intensity of aquaculture production

¶14 The SEEA EA notes that "there is the potential for data from the accounts to support climate change modelling focused on implications of projected climate change scenarios on economic activity" [29]. Combined presentations provide the integrated 'data foundation' for such analytical applications. In the ocean context, indicators derivable from ocean accounts include specific measures for ocean conditions such as acidification and concentrations of marine debris, as well as indicators for ocean-related beneficiaries such as income of small-scale fishers [28].

Communication for decision-making

¶1 Effective communication of combined presentations requires attention to audience needs. Key considerations include:

¶2 **Policy relevance**: Combined presentations should be organised around policy questions, not accounting structures. For example, a presentation addressing coastal resilience might draw on ex-

DRAFT

tent accounts (mangrove coverage), condition accounts (ecosystem health), economic accounts (coastal protection infrastructure), and social accounts (vulnerable populations).

¶3 **Accessibility**: Technical accounting detail should be supported by summary visualisations and plain-language interpretation. The SEEA EA notes that combined presentations "can be a useful tool for mainstreaming discussion" of environmental themes in broader policy discourse [30].

¶4 **Transparency**: Combined presentations should document data sources, methods, and limitations, enabling users to assess confidence in the information presented. Quality assurance considerations from **TG-0.7 Quality Assurance Principles** apply to combined presentations.

3.6 Extended Balance Sheets

¶1 Extended balance sheets are a specific type of combined presentation that integrates natural capital with conventional national balance sheets, supporting whole-of-ocean wealth accounting.

Conceptual framework

¶1 The 2025 SNA describes how balance sheets record the value of assets and liabilities at the beginning and end of accounting periods, with the balancing item being net worth [31]. For whole-of-economy wealth accounting, the scope of assets can be extended to include natural assets not traditionally recorded in national balance sheets.

¶2 For ocean accounting, extended balance sheets incorporate:

¶3 **Produced assets** including vessels, ports, aquaculture infrastructure, and offshore energy installations. These are recorded in conventional national balance sheets and can be allocated to ocean-related sectors. The SEEA EA notes that ocean wealth includes "produced assets (e.g. ports)" [32].

¶4 **Non-produced natural assets** including:

- ¶5 Marine fish stocks and other aquatic resources (see **TG-3.1 Asset Accounts**, Section 3.3)
- ¶6 Seabed mineral and energy resources (see **TG-3.10 Offshore Energy Accounts**)
- ¶7 Coastal land resources

¶8 **Ecosystem assets** representing the monetary value of marine and coastal ecosystems. The SEEA EA provides guidance on valuing ecosystem assets using net present value of expected ecosystem service flows [33]. Valuation follows the methods described in **TG-1.9 Safe Usage of Monetary Valuation**.

Ocean wealth indicators

¶1 Extended balance sheets support derivation of ocean wealth indicators that complement flow-based measures like ocean economy GDP:

¶2 **Total ocean wealth**: The aggregate value of all ocean-related assets, including produced assets, natural resources, and ecosystem assets.

¶3 **Ocean wealth per capita**: Total ocean wealth divided by population, providing a measure of the asset base supporting each person's potential ocean-derived wellbeing.

¶4 **Ocean wealth change**: The change in total ocean wealth between accounting periods, decomposed into:

- ¶5 Capital formation (investment in produced assets)
- ¶6 Natural growth (regeneration of renewable resources)
- ¶7 Depletion (extraction exceeding sustainable yield)
- ¶8 Degradation (decline in ecosystem asset values)
- ¶9 Revaluation (price changes)

DRAFT

¶10 **Ocean wealth sustainability**: The relationship between ocean wealth change and ocean economy output. Sustainable development implies that wealth is at least maintained over time; depletion of ocean wealth to support current consumption represents unsustainable use. This indicator connects to the sustainability indicators in **TG-2.11 Resource Efficiency Indicators**.

Limitations and caveats

¶1 Extended balance sheets for ocean wealth face several limitations that should be communicated in combined presentations:

¶2 **Valuation challenges**: Monetary valuation of ecosystem assets remains methodologically challenging, with the SEEA EA valuation chapters adopted as recommendations rather than full international standards [34] . Extended balance sheets should present valuations with appropriate uncertainty characterisation.

¶3 **Boundary issues**: Ecosystem assets may provide services beyond national economic territory, creating challenges for allocating values to national balance sheets. This is particularly relevant for migratory fish stocks and ecosystem services with transboundary effects. The SEEA EA notes the opportunity to compile global ocean accounts for areas beyond national jurisdiction, where much data are already collected by international agencies [35] .

¶4 **Non-substitutability**: Monetary aggregation of produced and natural assets may suggest substitutability that does not exist ecologically. Extended balance sheets should be accompanied by physical accounts that reveal whether natural asset decline is being offset by produced capital or represents genuine wealth loss.

¶5 The SEEA EA observes that "a comprehensive set of ocean accounts enables decision makers to monitor several critical trends" including "changes in ocean wealth, including produced assets (e.g. ports) and non-produced assets (e.g. mangroves, coral reefs)" [36] . Extended balance sheets provide the framework for this monitoring.

3.7 Integrated Ocean Dashboard Specification

¶1 Combined presentations carry the most policy weight when assembled into integrated ocean dashboards that present headline indicators across all four accounting domains (environmental, economic, social, and governance) in a single view. This section specifies the structure, indicator selection criteria, and layout for an ocean dashboard that can serve as the primary communication product of an ocean accounting programme. The dashboard design draws on the indicator categories identified in Table 1 (Section 3.5) and extends them into a fuller specification suitable for both printed reports and interactive web-based platforms.

Headline indicators by domain

¶1 An effective ocean dashboard presents a small number of headline indicators that together convey the overall status of the ocean-society relationship. The selection of headline indicators should satisfy three criteria: policy relevance (the indicator addresses a question that decision-makers actively consider), data availability (the indicator can be compiled from existing or planned accounts), and communicability (the indicator can be understood by non-specialist audiences). The following table specifies the recommended headline indicator set, organised by the four domains of the ocean accounts framework.

¶2 *Table 3.7.1: Integrated ocean dashboard headline indicators*

Domain	Headline Indicator	Unit	Account Source	Update Frequency
Environmental	Total marine and coastal ecosystem extent	km²	Ecosystem extent account (TG-3.1)	Annual

DRAFT

Domain	Headline Indicator	Unit	Account Source	Update Frequency
Environmental	Aggregate ecosystem condition index	Index (0-1)	Ecosystem condition account (TG-2.1)	Annual
Environmental	Fish stock status (proportion within biological limits)	%	Individual asset accounts (TG-3.1)	Annual
Environmental	Blue carbon stock (mangroves, seagrass, salt marsh)	Tonnes C	Ecosystem extent + condition accounts	Annual
Economic	Ocean economy GVA	Currency units	Thematic economic account (TG-3.3)	Annual
Economic	Depletion-adjusted ocean economy GVA	Currency units	Extended economic account (TG-3.3)	Annual
Economic	Ocean economy share of national GDP	%	Thematic economic account	Annual
Economic	Resource rent from ocean natural assets	Currency units	Asset accounts (TG-3.1) + valuation (TG-1.9)	Annual
Social	Ocean-dependent employment	Persons	Economic activity account (TG-3.5)	Annual
Social	Coastal community well-being index	Index	Social accounts (TG-3.5)	Biennial
Social	Income equity ratio (coastal vs national median)	Ratio	Distributional accounts (TG-3.5)	Annual
Social	Food security from marine sources (protein supply per capita)	kg/capita/yr	Flow accounts (TG-3.2) + social accounts	Annual
Governance	Marine protected area coverage	% of EEZ	Governance accounts (TG-3.7)	Annual
Governance	Ocean area under spatial planning	% of EEZ	Governance accounts (TG-3.7)	Annual
Governance	Management effectiveness score	Index	Governance accounts (TG-3.7)	Biennial
Governance	Environmental expenditure for ocean management	Currency units	Public expenditure accounts	Annual

DRAFT

¶3 Countries should adapt this indicator set to national circumstances, adding or replacing indicators to reflect priority policy questions. However, maintaining a consistent core set enables international comparison and benchmarking through the GOAP community of practice.

Dashboard layout template

¶1 The dashboard should follow a two-tier layout: a single-page summary providing the overall picture at a glance, and a set of drill-down pages providing detailed analysis for each domain. This structure allows the dashboard to serve multiple audiences: ministers and executives who need a rapid overview, and technical analysts who require detailed breakdowns.

¶2 The **single-page summary** should present the sixteen headline indicators in a quadrant layout (environmental top-left, economic top-right, social bottom-left, governance bottom-right), with each indicator showing the current value, the trend direction (improving, stable, or declining), and the percentage change from the previous period. A central panel should display one to three cross-domain integration indicators such as depletion-adjusted GVA per capita or the ratio of ecosystem service value to ocean economy output. Colour coding (green for improving, amber for stable, red for declining) provides immediate visual assessment, though the dashboard should remain interpretable in greyscale for printed reports and accessibility.

¶3 Each **drill-down page** should present the full indicator set for one domain, accompanied by time-series charts showing trends over a minimum of five years (where data permit), spatial maps showing geographic variation across the accounting area, and explanatory text highlighting key patterns and policy implications. The drill-down pages should cross-reference related indicators in other domains; for example, the environmental drill-down should note the economic value of ecosystem services, and the economic drill-down should flag depletion and degradation adjustments. Data tables supporting each drill-down page should be published as downloadable datasets in machine-readable formats, following the interoperability standards described in **TG-4.6 Data Harmonisation and Interoperability**.

¶4 *Table 3.7.2: Dashboard layout specification*

Component	Content	Format	Audience
Single-page summary	16 headline indicators in quadrant layout; trend arrows; cross-domain integration indicators	One page (A4/Letter); printable and web	Ministers, executives, media
Environmental drill-down	Extent trends by ecosystem type; condition indices; ecosystem service flows; pressure indicators	2-4 pages with charts and maps	Planners, environmental managers
Economic drill-down	GVA by industry; employment trends; trade balance; investment; depletion adjustments	2-4 pages with charts and tables	Finance ministry, planning commission
Social drill-down	Employment quality; income distribution; food security; vulnerability; cultural indicators	2-4 pages with charts and maps	Social policy, community development
Governance drill-down	Protected area trends; spatial planning coverage; management effectiveness; expenditure	2-4 pages with charts and maps	Governance agencies, oversight bodies
Data annex	Full indicator tables; metadata; quality notes; concordance documentation	Machine-readable download (CSV/SDMX)	Analysts, researchers

DRAFT

¶5 The dashboard should be updated annually in alignment with the national accounts publication cycle, with a target release date within twelve months of the reference period end. Interim updates for high-priority indicators (such as fish stock status or protected area coverage) may be published on a more frequent basis where data systems permit.

3.8 Cross-Domain Integration Protocol

¶1 Integrating data across environmental, economic, and social domains is the central difficulty of combined presentations. Whilst the compilation procedure in Section 3.4 describes the general workflow, this section provides a step-by-step protocol for linking specific account types across domain boundaries. The protocol addresses four integration pathways frequently encountered in ocean accounting: linking land accounts to coastal zone accounts, connecting water accounts to marine quality indicators, integrating blue carbon into national greenhouse gas inventories, and reconciling plastics flows with waste accounts.

Land accounts to coastal zone

¶1 Terrestrial land accounts compiled under the SEEA Central Framework and SEEA Ecosystem Accounting record land use and land cover for national territory, typically stopping at the coastline. Ocean accounts record marine and coastal ecosystem extent from the coastline seaward. The integration protocol bridges these two domains to provide a continuous picture of the land-sea interface, supporting analysis of how land-based activities affect coastal and marine ecosystems.

¶2 The protocol proceeds in four steps. First, establish a common spatial framework that encompasses both the terrestrial coastal strip (typically defined as the area within a specified distance of the mean high-water line, such as 5 km or 10 km) and the nearshore marine zone (extending to the limit of the coastal ecosystem types such as mangroves, seagrass, and nearshore reefs). The spatial framework guidance in **TG-2.12 Spatial Data Frameworks** provides the basis for this delineation. Second, reconcile the ecosystem type classification used in land accounts (often based on national land cover classifications mapped to the IUCN GET terrestrial and transitional realms) with the marine ecosystem type classification used in ocean accounts (based on GET marine realm). The concordance should explicitly address transitional ecosystems (mangroves, salt marshes, estuaries) that may appear in both land and ocean accounts, ensuring they are counted once and allocated consistently. Third, compile a linked extent account that shows land use change in the coastal strip alongside marine ecosystem extent change in the nearshore zone, enabling analysis of how coastal development drives marine habitat loss. Fourth, verify consistency by checking that land-based pollution loads recorded in the residual flow accounts (**TG-3.4**) are physically plausible given the land use composition of the coastal strip.

¶3 *Table 3.8.1: Land-coastal zone integration checklist*

Step	Action	Quality Check
1. Spatial framework	Define coastal strip and nearshore zone boundaries	Boundaries contiguous; no gaps or overlaps at coastline
2. Classification concordance	Map land cover classes to marine ecosystem types for transitional zone	Each transitional ecosystem allocated to exactly one domain
3. Linked extent account	Compile land use change and marine extent change in single table	Total area equals sum of terrestrial strip plus nearshore zone
4. Pollution flow consistency	Compare land-based pollution loads to coastal water quality	Nutrient loads from land accounts plausible given receiving water volumes

DRAFT

Water accounts to marine quality

¶1 Water accounts compiled under the SEEA Central Framework (Chapter 3) record water abstraction, use, and return flows within the hydrological cycle. Marine quality monitoring programmes measure concentrations of nutrients, sediments, and pollutants in coastal and marine waters. The integration protocol links these two information systems to enable analysis of how freshwater management decisions affect marine environmental quality.

¶2 The protocol requires, first, identifying the river basins and coastal catchments that discharge into the ocean accounting area. Water accounts for these catchments provide data on return flows (treated and untreated wastewater discharges) and diffuse pollution loads (agricultural runoff, urban stormwater). Second, the return flow data from water accounts should be expressed in terms of pollutant loads (tonnes of nitrogen, phosphorus, suspended sediments, and biochemical oxygen demand) rather than water volumes alone. This requires combining water volume data with concentration measurements, which may come from water quality monitoring stations operated by environmental agencies. Third, the pollutant loads should be linked to the residual flow accounts in **TG-3.4 Flows Economy to Environment**, which record emissions from economic activities to the marine environment. Fourth, the resulting pollutant load estimates should be reconciled with marine water quality observations from coastal monitoring programmes, checking that the estimated

loads are consistent with observed concentrations given the dilution and assimilative capacity of receiving waters. Discrepancies may indicate unaccounted pollution sources (such as atmospheric deposition or groundwater discharge) or errors in load estimation.

¶3 *Table 3.8.2: Water-marine quality integration protocol*

Data Source	Variables	Transformation	Ocean Account Destination
Water accounts (SEEA CF)	Return flow volumes by catchment	Multiply by pollutant concentrations	Residual flow accounts (TG-3.4)
Water quality monitoring	Pollutant concentrations at discharge points	Convert to load estimates (concentration x flow)	Residual flow accounts
Marine monitoring	Coastal water quality indices	Compare with estimated loads for consistency	Ecosystem condition accounts (TG-3.1 Section 3.5.2)
Agricultural statistics	Fertiliser application rates by crop and region	Apply runoff coefficients for diffuse load estimates	Residual flow accounts

Blue carbon to GHG inventories

¶1 Blue carbon integration links carbon stock data from ocean extent and condition accounts to national GHG inventories, ensuring consistent treatment of mangrove, seagrass, salt marsh, and kelp carbon flows under IPCC wetlands guidance. For the full blue carbon integration protocol, including the stock decomposition method, IPCC category mapping, and reconciliation checklist, see **TG-6.2 Mangrove and Coastal Wetland Accounting**.

Plastics to waste accounts

¶1 Marine plastic pollution is a priority policy concern that requires integration of data from waste accounts (recording plastic waste generation, collection, and disposal), residual flow accounts (recording plastic leakage to the marine environment), and marine debris monitoring (recording plastic concentrations in coastal and marine waters). The integration protocol links these data streams to provide a complete material flow account for plastics from production through to marine accumulation.

¶2 The protocol begins with the waste accounts compiled under the SEEA Central Framework, which record waste generation by economic activity and waste management (collection, recycling, disposal) by waste type. Compilers should extract plastic waste flows from the waste accounts, using the relevant waste classification categories. Second, plastic leakage to the marine environment should be estimated using a combination of waste management data (uncollected waste, landfill leakage) and pathway analysis (riverine transport, coastal littering, maritime sources). The pollution flow accounts in **TG-2.7 Pollution and Other Flows** provide guidance on estimating residual flows. Third, marine debris monitoring data (beach surveys, trawl surveys, remote sensing) should be compiled as condition indicators for the relevant marine ecosystem types, following the condition accounting guidance in **TG-2.1 Aggregate Biophysical Indicators of Environmental State**. Fourth, the complete material flow should be reconciled: total plastic production minus recycling minus managed disposal minus exports should equal domestic accumulation (in landfills and the environment) plus marine leakage, within estimation tolerances. Discrepancies should be investigated and documented.

¶3 *Table 3.8.4: Plastics material flow reconciliation*

DRAFT

Flow Component	Data Source	Unit	Quality Check
Plastic production + imports	Industry statistics, trade data	Tonnes/yr	Cross-check with customs data
Plastic exports	Trade data	Tonnes/yr	Verify with partner country import data
Managed disposal (landfill, incineration)	Waste management records	Tonnes/yr	Sum of disposal routes equals collected waste
Recycling	Waste management records	Tonnes/yr	Recycling rate within plausible range for country
Uncollected waste	Estimated from collection coverage	Tonnes/yr	Consistent with population and collection infrastructure
Marine leakage	Pathway analysis + monitoring	Tonnes/yr	Plausible given uncollected waste and proximity to coast
Balance check	Production + imports − exports = disposal + recycling + accumulation + leakage	Tonnes/yr	Residual within 10% tolerance

3.9 Sub-National Combined Presentations

¶1 Many ocean governance decisions are made at sub-national scales: by provincial governments, municipal authorities, port authorities, and local marine management bodies. This section provides guidance on adapting the combined presentation format for sub-national application, recognising that sub-national compilers typically face more constrained data environments and require simplified indicator sets that can be compiled with available resources.

Adapting the framework for provinces and municipalities

¶1 The ocean accounts framework and the combined presentation structure described in Sections 3.1 through 3.8 are designed primarily for national-level application, but the SEEA EA explicitly notes that accounting principles are applicable across different spatial scales. Sub-national combined presentations follow the same general structure (environmental, economic, social, and governance domains) but require adaptation in three areas: spatial scope, data sources, and indicator selection.

¶2 For **spatial scope**, sub-national combined presentations should define the accounting area with reference to existing administrative boundaries (province, district, municipality) and the adjacent marine area over which the sub-national authority exercises jurisdiction or management responsibility. Where the sub-national authority does not have formal marine jurisdiction, the accounting area may be defined as the coastal zone within its terrestrial boundary plus a seaward extension agreed with the national ocean accounting programme. The spatial unit guidance in **TG-2.12 Spatial Data Frameworks** applies, with the additional requirement that the sub-national accounting area should nest within the national accounting area to enable aggregation.

¶3 For **data sources**, sub-national compilers will often lack the detailed economic statistics available at national level (such as supply-use tables or detailed industry GVA by sub-national region). Available data may include regional employment statistics, local government revenue data, fisheries landing records from local ports, and environmental monitoring from sub-national agencies. Remote sensing data (**TG-4.1 Remote Sensing and Geospatial Data**) and citizen science data (**TG-4.4 Citizen Science**) can supplement official statistics at the sub-national level.

¶4 For **indicator selection**, sub-national presentations should use a simplified indicator set that can be compiled with available data whilst still covering the four domains. The following table provides a recommended minimum indicator set for sub-national combined presentations.

DRAFT

¶5 *Table 3.9.1: Simplified indicator set for sub-national combined presentations*

Domain	Indicator	Minimum Data Requirement	Compilation Difficulty
Environmental	Coastal and marine ecosystem extent	Satellite imagery + national land cover map	Low
Environmental	Key ecosystem condition indicator (e.g., water quality index)	Local monitoring station data	Medium
Environmental	Fish stock indicator (e.g., CPUE from local fleet)	Local fisheries landing records	Medium
Economic	Local ocean economy employment	Regional labour force survey or census	Low
Economic	Fisheries landing value	Port landing records	Low
Economic	Tourism visitor numbers and expenditure	Local tourism statistics	Low-Medium
Social	Coastal community population and demographics	Census data	Low
Social	Households dependent on ocean livelihoods	Household survey or census	Medium
Social	Access to marine-related services (e.g., sanitation near coast)	Administrative records	Low
Governance	Local MPA or managed area coverage	Protected area registry	Low
Governance	Compliance and enforcement indicators	Local management authority records	Medium
Governance	Local government ocean-related expenditure	Budget records	Low

¶6 This simplified set of twelve indicators represents the minimum viable combined presentation for a sub-national area. As data systems mature, additional indicators from the full national dashboard specification (Section 3.7) can be incorporated.

DRAFT

Aggregation and consistency with national accounts

¶1 Sub-national combined presentations must be designed for aggregation to the national level. This requires that sub-national accounting areas are exhaustive (every part of the national accounting area belongs to exactly one sub-national unit) and mutually exclusive (no overlaps). Classification systems used at the sub-national level must be consistent with national classifications, or concordance tables must be maintained to enable consistent aggregation. Where sub-national data are compiled independently by multiple agencies, a coordination mechanism is needed to ensure consistent boundary definitions, classification application, and temporal reference periods. The data harmonisation guidance in **TG-4.6 Data Harmonisation and Interoperability** provides the technical framework for this coordination.

¶2 The relationship between sub-national and national combined presentations should be documented in metadata, specifying: the nesting hierarchy of spatial units, any allocation methods used to distribute national data to sub-national areas (such as pro-rata allocation of national GVA based on employment shares), and any sub-national data that are compiled independently and aggregated upward to the national total. Where discrepancies arise between the sum of sub-national accounts and independently compiled national accounts, these should be treated as statistical discrepancies and documented transparently, following the quality assurance guidance in **TG-0.7 Quality Assurance Principles**.

Link to TG-3.11

¶1 Sub-national combined presentations are a key input to the compilation of ocean sustainability reports at local and regional scales. **TG-3.11 Sub-National Ocean Accounts** provides guidance on linking sub-national accounts to local planning processes and on dashboards for local decision-makers (its Sections 3.5 and 3.6). While combined presentations maintain the formal accounting structure (tables, indicators, and methodological documentation), sustainability reports translate these into accessible narratives with policy recommendations. Sub-national authorities preparing sustainability reports should compile the simplified combined presentation described in this section as the data foundation, then apply the local-planning and dashboard guidance in TG-3.11 to produce the final report. The feedback loop between reporting requirements and data compilation priorities should inform progressive improvements in sub-national data collection, with the most policy-relevant indicators receiving priority investment in data quality and timeliness.

3.10 Worked Example: Integrated Coastal Zone Combined Presentation

¶1 This section presents a worked example demonstrating how to compile a combined presentation for a hypothetical coastal zone. The example uses synthetic data to illustrate the compilation procedure described in Section 3.4, showing how component accounts are assembled into an integrated presentation that answers a specific policy question.

Scenario and policy question

¶1 **Policy question**: Is coastal development in the Northshore Zone proceeding sustainably, balancing economic growth with conservation of marine ecosystems and coastal protection services?

¶2 **Accounting area**: Northshore Coastal Zone, encompassing 50 km of coastline, extending 12 nautical miles offshore, with total area of approximately 1,200 km² (at start of period: 152 km² of mangroves, 82 km² of seagrass meadows, 605 km² of coral reef ecosystems, and 370 km² of continental shelf waters).

¶3 **Reference period**: Calendar year 2025.

¶4 **Primary users**: Regional development authority, national planning ministry, coastal zone management agency.

DRAFT

Step 1: Component accounts assembled

¶1 The following accounts were available for the reference period:

¶2 **Environmental accounts**:

- ¶3 Ecosystem extent account (from satellite analysis and field surveys)
- ¶4 Ecosystem condition account (from monitoring stations)
- ¶5 Fish stock asset account (from stock assessment)
- ¶6 Ecosystem services flow account (physical measures only; partial monetary valuation)

¶7 **Economic accounts**:

- ¶8 Ocean economy thematic account for Northshore Zone (GVA by industry)
- ¶9 Employment account (by industry and demographic group)
- ¶10 Tourism expenditure account

¶11 **Social accounts**:

- ¶12 Household distributional account (income by coastal/inland residence)
- ¶13 Employment by gender and age group

¶14 **Governance accounts**:

- ¶15 Protected area coverage (marine protected area extent and status)

¶16 **Data limitations**: Monetary valuation of regulating services (coastal protection, carbon sequestration) incomplete; governance effectiveness indicators not quantified; full supply-use tables not available.

Step 2: Combined presentation structure

¶1 Based on the policy question, the presentation is structured into four integrated sections:

¶2 **Section A: Environmental status and trends** (extent, condition, services) **Section B: Economic activity and benefits** (GVA, employment, income) **Section C: Sustainability indicators** (depletion, degradation, pressure-state relationships) **Section D: Governance and management response** (protected areas, expenditure)

Section A: Environmental Status and Trends

¶1 **Table 2: Ecosystem Extent and Condition (2025)**

Ecosystem Type	Opening Extent (km²)	Closing Extent (km²)	Net Change (km²)	Aggregate Condition Index (0-1)	Change in Condition
Mangroves	152	150	-2	0.68	-0.03
Seagrass meadows	82	80	-2	0.71	-0.05
Coral reefs	605	600	-5	0.58	-0.07
Continental shelf	370	370	0	0.64	-0.02
Total	1,209	1,200	-9	0.62 (area-weighted)	-0.04

¶2 **Interpretation**: The coastal zone experienced net loss of 9 km² of ecosystem extent during 2025, driven by conversion of mangroves and seagrass to coastal development and degradation of coral reef systems. Condition indices declined across all ecosystem types, with coral reefs showing the most significant decline (0.07 reduction in condition index). The aggregate condition index (area-weighted average) for the zone fell from 0.67 to 0.62, indicating widespread ecosystem stress.

DRAFT

¶3 **Table 3: Physical Ecosystem Service Flows (2025)**

Ecosystem service	Unit	Mangrove	Seagrass	Coral reef	Total supply	Primary users
Fish provisioning	tonnes/yr	450	280	1,120	1,850	Commercial fisheries (1,620 t), Subsistence fishing (230 t)
Coastal protection	km protected	27	6	17	50	Coastal properties, infrastructure
Carbon sequestration	tonnes C/yr	1,800	640	120	2,560	Global community (climate regulation)
Recreation	visitor-days/yr	8,000	12,000	95,000	115,000	Tourism operators, households

¶4 **Interpretation**: Coral reefs provide the majority of fish provisioning services (1,120 of 1,850 tonnes), whilst mangroves contribute the most to carbon sequestration (1,800 of 2,560 tonnes carbon per year) and coastal protection (27 of 50 km protected, after the 15 km of coastline protected by more than one type is allocated in proportion to each type's share so that no stretch is counted twice). Recreation services are heavily concentrated in coral reef areas (95,000 of 115,000 visitor-days).

¶5 **Table 4: Fish Stock Asset Account (2025)**

Entry	Value (tonnes)
Opening stock (1 Jan 2025)	18,500
Additions	
Natural growth	3,200
Reductions	
Commercial catch	1,620
Subsistence catch	230
Natural mortality	2,150
Closing stock (31 Dec 2025)	17,700
Sustainability measures	
Sustainable yield (MSY estimate)	1,500
Actual catch	1,850
Depletion	350

¶6 **Interpretation**: Fish stock declined by 800 tonnes (4.3%) during 2025. Actual catch (1,850 tonnes) exceeded sustainable yield (1,500 tonnes) by 350 tonnes, indicating overfishing and resource depletion. At current extraction rates, fish stocks will continue to decline unless catch is reduced.

Section B: Economic Activity and Benefits

¶1 **Table 5: Ocean Economy Contribution (2025, million USD)**

Industry	GVA	Employment (persons)	Share of Zone GVA (%)
Marine fishing	12.5	620	8.2
Aquaculture	3.8	180	2.5
Coastal tourism	45.2	1,350	29.6
Maritime transport (port services)	8.6	240	5.6
Coastal construction	15.3	890	10.0
Other ocean-related	4.1	320	2.7
Total ocean economy	89.5	3,600	58.6
Non-ocean economy	63.2	2,800	41.4
Total zone economy	152.7	6,400	100.0

DRAFT

¶2 **Interpretation**: Ocean-related industries account for 58.6% of the zone's gross value added and 56% of employment. Coastal tourism is the dominant sector (29.6% of GVA, 1,350 employees), followed by coastal construction (10.0% of GVA) and marine fishing (8.2% of GVA). The zone's economy is heavily dependent on ocean resources and marine ecosystem health.

¶3 **Table 6: Income Distribution (2025, households by location)**

Indicator	Coastal Households	Inland Households	Zone Average
Median annual income (USD)	18,400	22,600	20,200
Share employed in ocean economy (%)	64	28	48
Households below poverty line (%)	22	14	18

¶4 **Interpretation**: Coastal households earn 18% less than inland households on average and have higher poverty rates (22% versus 14%), despite higher dependence on ocean economy employment

(64% versus 28%). This suggests that ocean economy jobs, particularly in fishing and aquaculture, provide lower incomes than inland employment, and that coastal communities are economically vulnerable to changes in marine resource availability.

Section C: Sustainability Indicators

¶1 **Table 7: Integrated Sustainability Indicators (2025)**

Indicator	Value	Interpretation
Resource efficiency		
GVA per tonne of fish caught (USD/tonne)	6,757	Fisheries generate USD 6,757 of value added per tonne of catch
Tourism GVA per km² of coral reef (USD thousand/km²)	75.3	Each km² of coral reef supports USD 75,300 of tourism GVA
Sustainability		
Catch as % of sustainable yield	123%	Overfishing: catch exceeds sustainable yield by 23%
Depletion as % of fisheries GVA	2.8%	Depletion valued at resource rent of USD 1,000/tonne (350 tonnes x USD 1,000 = USD 350,000), representing 2.8% of fisheries GVA (USD 12.5M)
Ecosystem extent change (%)	-0.7%	Ecosystem extent declined by 0.7% during the year
Pressure intensity		
Nutrient loads per unit coastal development (tonnes N/km²)	3.2	Each km² of development generates 3.2 tonnes of nutrient pollution
Tourist visitors per km² of reef	158	Coral reef areas receive 158 visitor-days per km² per year

¶2 **Interpretation**: The zone shows clear signs of unsustainable use. Fish catch exceeds sustainable levels by 23%, leading to stock depletion that reduces the net income from fisheries by 2.8%. Ecosystem extent is declining, and condition indices are falling across all ecosystem types. Nutrient pollution from coastal development and visitor pressure on coral reefs are contributing to ecosystem stress.

DRAFT

Section D: Governance and Management Response

¶1 **Table 8: Governance and Management Indicators (2025)**

Indicator	Value	Target	Gap
Marine protected area coverage (km²)	180	300	-120
MPA coverage as % of zone area	15.0%	25.0%	-10.0%
Government expenditure on coastal management (million USD)	2.4	–	–
Coastal management expenditure per km² (USD thousand/km²)	2.0	–	–
Enforcement patrol days	120	180	-60

¶2 **Interpretation**: Marine protected area coverage (15%) falls short of the national target (25%), with 120 km² additional area requiring designation to meet the target. Government expenditure on coastal management (USD 2.4 million, or USD 2,000 per km²) may be insufficient given the level of ecosystem stress observed. Enforcement capacity (120 patrol days) is below the planned level (180 days), suggesting monitoring and compliance challenges.

Section E: Balance Sheet and Adjusted Aggregates

¶1 The four sections above present accounts side by side. This one brings them onto a single line. Two presentations do that: the ocean balance sheet, which states what the zone owns at a point in time, and the adjusted aggregates derivation, which states what it earned after the cost of running its natural capital down.

¶2 **The ocean balance sheet.** Assembled from the closing stocks of the asset accounts, produced and non-produced together. It is the presentation **TG-3.1** Section 3.2 Step 6 names as the integration point for asset accounts, and the only one in which produced and environmental capital appear on comparable terms.

¶3 **Table 9: Ocean balance sheet — structural template**

	Opening	Closing	Change
Non-financial assets			
Produced assets — vessels, aquaculture, energy, port, coastal protection	[value]	[value]	[+/-]
Non-produced natural resources — aquatic, mineral and energy, water	[value]	[value]	[+/-]
Ecosystem assets	[value]	[value]	[+/-]
Financial assets	[value]	[value]	[+/-]
Less: liabilities (incl. decommissioning provisions)	[-value]	[-value]	[+/-]
Net worth	**[value]**	**[value]**	**[+/-]**

¶4 *Table 9: Structural template of an ocean balance sheet. Produced asset values come from the TG-3.1 Table 10 template, natural resources from Table 1b, ecosystem assets from Table 4. Decommissioning provisions are a liability, not a negative asset.*

¶5 **Adjusted aggregates.** Gross value added measures production without charging for the natural capital consumed in producing it. The adjustment deducts consumption of fixed capital, as the SNA already does for produced assets, and then deducts depletion and degradation, which the SNA does not. The 2025 SNA treats depletion of natural resources as a cost of production analogous to depreciation, so the deduction is not an alternative accounting — it is the completion of the existing one.

¶6 **All three deductions must be at constant prices.** Holding gains are not income. TG-3.1 Section 3.7 shows an ecosystem account closing above its opening value in a year when extent, condition and biomass all fell, purely on revaluation; an adjusted aggregate that netted revaluation into the deduction would inherit that error.

DRAFT

¶7 **Table 10: Adjusted ocean aggregates — derivation**

Line	Source	Value (million USD)
Ocean economy gross value added	Table 5	89.50
less consumption of fixed capital	Produced asset account	(7.20)
Net ocean value added		**82.30**
less depletion of natural resources, at constant prices	Table 4 depletion x resource rent (350 t x USD 1,000/t)	(0.35)
less ecosystem degradation, at constant prices	Condition index decline x opening ecosystem asset value	(2.85)
Environmentally adjusted net ocean value added		**79.10**
Memorandum: adjustment as a share of GVA		*3.6%*
Memorandum: revaluation excluded from the above	Asset accounts	*4.10*

¶8 *Table 10: Derivation of environmentally adjusted net ocean value added for the Northshore Coastal Zone, 2025. Every line traces to an account compiled above or to the produced asset account in TG-3.1 Section 3.6.*

¶9 **Reading the derivation.** The zone's ocean economy reports USD 89.5 million of gross value added. USD 7.2 million of that is the using-up of vessels, ponds and port structures, and a further USD 3.2 million is the using-up of fish stocks and ecosystem condition. Net of both, the zone earned USD 79.1 million — 11.6 per cent less than the headline, and 3.6 per cent less than a conventional net measure that stops at produced capital.

¶10 The memorandum line is the one to watch over a run of years. USD 4.1 million of holding gains sat in the asset accounts this period, more than the entire natural capital deduction. A presentation that reported change in net worth without separating that line would show the zone's ocean wealth broadly flat while its fish stocks fell 4.3 per cent, its reefs lost 5 km² and every condition index declined.

¶11 **A caution on completeness.** This derivation charges only for what has been measured. Degradation here covers the ecosystem types with condition accounts; services without a defensible valuation contribute nothing to the deduction, which biases the adjusted figure upwards. State what the deduction covers whenever the number is published, or it will be read as comprehensive.

Step 3: Integration and policy implications

¶1 *The tables above together show declining condition alongside rising GVA; the gap between sustainable yield and actual harvest signals resource depletion; and distributional data reveal that coastal households bear a disproportionate share of ecosystem stress. Together these warrant the policy adjustments described in the scenario narrative.*

3.11 Condition-to-Services Data-Flow Integration

¶1 Combined presentations that span condition and services require a structured linkage from condition account outputs to ecosystem service account inputs. The three-step pattern (inventory condition outputs, map them to service inputs, then assemble an integrated extent-condition-service table) operationalises the SEEA EA articulation of these accounts as a connected sequence [37]. Compilers should apply the service-specific methods and indicator guidance in **Section 3.2** and the linked TG-2.x circulars when selecting indicators and conversion factors.

DRAFT

4. Summary

¶1 Combined presentations integrate data from multiple account types to support analysis and decision-making for ocean governance. Key principles include:

1. ¶2
   Consistency: Combined presentations draw on underlying accounts compiled using consistent geographical boundaries, entity definitions, and classifications.
2. ¶3
   Complementarity: Physical, monetary, social, and governance data provide complementary perspectives that together support fuller analysis.
3. ¶4
   Policy orientation: Effective combined presentations are organised around policy questions, not accounting structures, with visualisations designed for decision-making audiences.
4. ¶5
   Transparency: Methods, data sources, and limitations should be clearly documented to support informed interpretation.

¶6 Combined presentations are the analytical endpoint of the ocean accounts framework, enabling the derivation of integrated indicators and supporting the mainstreaming of ocean sustainability into national policy and decision-making.

Implementation Considerations

¶1 For minimum institutional capacity, data infrastructure, and human skills requirements for compiling these accounts, see TG-0.8 Implementation Readiness Assessment. For guidance on adapting these methods to sub-national scales, see TG-3.11 Sub-National Ocean Accounts.

5. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

6. References

1. ¶1 SEEA EA (2021), para. 13.1. "The framing provided by ecosystem accounting is systematic and comprehensive with respect to ecosystem extent, ecosystem condition and ecosystem services and offers one perspective on monetary values of ecosystem services and ecosystem assets."
2. ¶2 SEEA EA (2021), para. 13.1. "Policy and analysis related to the environment and human connection to it can be framed in many ways. Often, it requires consideration of specific environmental themes, such as biodiversity, climate change, oceans and urban areas, among many others."
3. ¶3 SEEA EA (2021), para. 13.81. "A comprehensive set of ocean accounts enables decision makers to monitor several critical trends: (a) changes in ocean ecosystem extent and condition and in associated flows of ecosystem services; (b) changes in ocean wealth, including produced assets (e.g. ports) and non-produced assets (e.g. mangroves, coral reefs); (c) ocean-related income and welfare for different groups of people (e.g. income from fisheries for local communities); (d) ocean-based economic production (e.g. GDP from sectors deemed to be ocean-related); (e) changes in how oceans are governed and managed."
4. ¶4 SEEA EA (2021), para. 13.90. "Much of the information required to compile ocean accounts is common to other communities of practice including those for marine spatial planning, disaster risk and climate change. One objective of the ocean accounting community of practice is to ensure that these common data are standardized and shared."
5. ¶5 SEEA EA (2021), Figure 2.1 "General ecosystem accounting framework."
6. ¶6 SEEA EA (2021), para. 13.83. See Figure 13.2 "Coverage of the ocean accounts framework."
7. ¶7 SEEA EA (2021), paras. 13.5-13.7. "First, there needs to be a clearly agreed geographical area... Second, it is necessary to have a set of entities that are the focus of accounting... Third, in accounting for a single theme, multiple accounts are required."
8. ¶8 SEEA EA (2021), para. 13.8. "Links between the various accounts for a theme are possible because of the use of a clearly delineated and consistently applied geographical boundary and consistent application of classifications for agreed entities. This allows the accounts for one theme to convey a coherent narrative."
9. ¶9 SEEA EA (2021), paras. 13.9-13.10. "For any given thematic accounting exercise, there is no a priori restriction on the geographical area, type of entity or classification that must be applied." and "Accounting principles are themselves equally applicable across different spatial scales and entities and are unaffected by the choice of classification. These choices should therefore be made with a focus on the use of the accounts, including the potential to compare results over time and in different locations."
0. ¶10 SEEA EA (2021), Figure 2.2 "Connections between ecosystem accounts."
1. ¶11 SEEA CF (2012), para. 5.1. Asset accounts "record the stock of environmental assets at the beginning and end of each accounting period and the changes in the stock during the accounting period."
2. ¶12 SEEA CF (2012), Chapter IV describes environmental activity accounts including hybrid formats integrating physical and monetary data.
3. ¶13 SEEA EA (2021), Chapter 7 describes physical supply and use tables for ecosystem services.
4. ¶14 SEEA EA (2021), para. 7.1. "Ecosystem services flow accounts record the supply of ecosystem services by ecosystem assets and the use of those services by economic units."
5. ¶15 SEEA EA (2021), para. 13.92. "The ocean accounts framework has proved effective in supporting several pilot studies, each of which has aimed towards answering policy-relevant questions." Pilots in Samoa, Thailand, Viet Nam, China, and Malaysia are described.
6. ¶16 SEEA CF (2012), para. 5.457. "A commonly used indicator that is closely associated with the stock of aquatic resources, and in particular with fish, is the catch per unit of effort (CPUE)."
7. ¶17 SEEA EA (2021), para. 12.4. The chapter on integrated and extended presentations discusses relationships between physical and monetary data.
8. ¶18 2025 SNA, Chapter 34 (Measuring Well-being) and Chapter 35 (Measuring the Sustainability of Well-being). "A unique feature of the 2025 SNA is the broadening of the national accounts framework to better account for elements affecting wellbeing and sustainability."
9. ¶19 United Nations SDG Indicator 14.5.1. See also SEEA EA para. 13.94 on ocean account indicators.

DRAFT

0. ¶20 SEEA EA (2021), para. 13.89. "The objective of the ocean governance accounts is to provide spatially explicit location-based information so that decision makers and planners can make the most effective decisions with respect to ensuring the sustainable use of the ocean."
1. ¶21 SEEA CF (2012), para. 6.56. "Different forms of combined physical and monetary presentations are possible and, indeed, there is no standard form for these presentations or accounts... Ultimately, the structures of combined presentations of monetary and physical data are dependent on the availability of data and the question under investigation."
2. ¶22 SEEA CF (2012), para. 6.88. "The monetary accounts and tables are compiled using a consistent set of classifications of products and industries as used in the SNA. For physical data, different classifications are often used for different topics and themes that are specifically developed for analysis of those topics... Any differences in classification need to be resolved before physical and monetary data are combined."
3. ¶23 SEEA CF (2012), para. 6.71. "It is important to ensure that the source data underpinning the physical and the monetary data relate to the same accounting period."
4. ¶24 SEEA CF (2012), Table 6.4 and para. 6.122. "Table 6.4 sets out a possible structure and some typical content for the presentation of combined physical and monetary data. It has four sections, covering monetary flows, physical flows, stocks and flows of environmental and fixed assets, and relevant indicators."
5. ¶25 SEEA CF (2012), para. 6.91. "It is therefore important, when combining monetary and physical data, to confirm that the implicit relationships between quantities and prices are meaningful and reasonable."
6. ¶26 SEEA CF (2012), para. 6.59. "Because these presentations combine physical data that may be of more immediate relevance to scientists, with monetary data familiar to economists, they also have the potential to serve as a bridge between both types of specialists in the context of their analysis of the environment."
7. ¶27 SEEA CF (2012), Chapter VI describes applications and combined presentations.
8. ¶28 SEEA EA (2021), paras. 13.93-13.96 and Appendix A13.3. "In the context of ecosystems, the ocean may be viewed as a set of marine, coastal and transitional ecosystem types and any indicators derivable from SEEA EA can also be derived from the ocean accounts."
9. ¶29 SEEA EA (2021), para. 13.74. "There is also the potential for data from the accounts to support climate change modelling focused on implications of projected climate change scenarios on economic activity."
0. ¶30 SEEA EA (2021), para. 13.46. Combined presentations "can be a useful tool for mainstreaming discussion of biodiversity."
1. ¶31 2025 SNA, Chapter 13 describes balance sheets.
2. ¶32 SEEA EA (2021), para. 13.81.
3. ¶33 SEEA EA (2021), Chapter 10 describes principles of valuation for ecosystem assets.
4. ¶34 SEEA EA (2021), the monetary valuation chapters (Chapters 8-11, covering monetary ecosystem service accounts and monetary ecosystem asset accounts) were adopted by the UN Statistical Commission as recommendations rather than full international standards, pending further methodological development.
5. ¶35 SEEA EA (2021), para. 13.91. "The ocean is mostly an area beyond national jurisdiction (ABNJ). This introduces the opportunity to compile global ocean accounts, where much of the data are already collected by international agencies."
6. ¶36 SEEA EA (2021), para. 13.81.
7. ¶37 SEEA EA (2021), Chapter 2 and Figure 2.2 describe the connected sequence of ecosystem extent, condition, and service accounts, with condition variables informing the supply of ecosystem services.

DRAFT

Aquaculture Accounts

Provides guidance on compiling accounts for aquaculture within ocean accounting frameworks.

Version 0.7.5 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

OUTCOME

This Circular provides guidance on compiling accounts for aquaculture within ocean accounting frameworks, addressing the distinction between cultivated biological resources (produced assets within the SNA production boundary) and natural biological resources (wild fisheries). Aquaculture is a large and growing component of global seafood production, with distinct accounting requirements that differ markedly from wild-capture fisheries.

Aquaculture accounts serve several decision use cases for governments managing blue food systems and coastal development. They inform sustainable aquaculture planning by quantifying production capacity, tracking environmental pressures from aquaculture operations (nutrient loading, habitat conversion), and identifying trade-offs between aquaculture expansion and ecosystem conservation. They support carrying capacity assessment by comparing actual production against environmental limits. This enables authorities to set appropriate licensing thresholds for coastal zones and marine areas. They enable GBF Target 10 reporting by tracking area under sustainable aquaculture management and documenting environmental impacts that must be minimised under the Kunming-Montreal Global Biodiversity Framework. They also provide the evidence base for blue economy investment decisions by showing whether aquaculture growth is economically productive whilst remaining within ecological boundaries. These functions connect directly to the policy frameworks described in TG-1.2 OA and Marine Spatial Planning and TG-1.5 OA and Fisheries Management, where aquaculture accounts provide quantitative evidence for balancing food security objectives against environmental sustainability.

The guidance covers production boundary treatment, asset classification for aquaculture stocks, carrying capacity and sustainable production considerations, and environmental interactions including feed inputs and waste outputs. This Circular provides the accounting foundation for the thematic methodologies in TG-6.8 Aquaculture Thematic Methods.

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 4
3.1 Production Boundary Treatment 4
3.2 Compilation Procedure 6
3.3 Asset Classification 10
3.4 Carrying Capacity Considerations 12
3.5 Environmental Interactions 14
3.6 Worked Examples 16
3.7 Provisioning-Service Quantification: Linking Aquaculture Output to Ecosystem Service Accounts 20
4. Acknowledgements 23
5. References 23

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Aquaculture Accounts (2026) (GOAP Technical Guidance on Ocean Accounting, TG-3.9, v0.7.5). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-3/3-9-aquaculture/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

¶1 **Framework Position**

¶2 TG-3.9 sits within Section 3 (Accounts Compilation) and provides the aquaculture-specific application of the produced-asset accounting principles introduced in TG-3.1. It is the primary compilation reference for aquaculture and the direct methodological foundation for TG-6.8.

1. Outcome

¶1 This Circular provides guidance on compiling accounts for aquaculture within ocean accounting frameworks, addressing the distinction between cultivated biological resources (produced assets within the SNA production boundary) and natural biological resources (wild fisheries). Aquaculture is a large and growing component of global seafood production, with distinct accounting requirements that differ markedly from wild-capture fisheries[1].

¶2 Aquaculture accounts serve several decision use cases for governments managing blue food systems and coastal development. They inform sustainable aquaculture planning by quantifying production capacity, tracking environmental pressures from aquaculture operations (nutrient loading, habitat conversion), and identifying trade-offs between aquaculture expansion and ecosystem conservation. They support carrying capacity assessment by comparing actual production against environmental limits. This enables authorities to set appropriate licensing thresholds for coastal zones and marine areas. They enable GBF Target 10 reporting by tracking area under sustainable aquaculture management and documenting environmental impacts that must be minimised under the Kunming-Montreal Global Biodiversity Framework. They also provide the evidence base for blue economy investment decisions by showing whether aquaculture growth is economically productive whilst remaining within ecological boundaries. These functions connect directly to the policy frameworks described in **TG-1.2 OA and Marine Spatial Planning** and **TG-1.5 OA and Fisheries Management**, where aquaculture accounts provide quantitative evidence for balancing food security objectives against environmental sustainability.

¶3 The guidance covers production boundary treatment, asset classification for aquaculture stocks, carrying capacity and sustainable production considerations, and environmental interactions including feed inputs and waste outputs. This Circular provides the accounting foundation for the thematic methodologies in **TG-6.8 Aquaculture Thematic Methods**.

DRAFT

2. Requirements

¶1 This Circular requires familiarity with:

- ¶2 **TG-0.1 General Introduction to Ocean Accounts**: conceptual framework and key components of Ocean Accounts
- ¶3 **TG-0.2 Overview of Relevant Statistical Standards**: methodological foundations in SNA 2025, SEEA CF, and SEEA EA
- ¶4 **TG-3.1 Asset Accounts**: general methodology of physical and monetary asset accounts
- ¶5 **TG-3.3 Economic Activity Relevant to the Ocean**: industry classification framework for aquaculture

¶6 **Related Circulars:**

- ¶7 **TG-1.5 OA and Fisheries Management**: broader fisheries management context
- ¶8 **TG-3.2 Flows from Environment to Economy**: natural resource inputs used by aquaculture
- ¶9 **TG-3.4 Flows from Economy to Environment**: aquaculture residual flows to the environment
- ¶10 **TG-2.7 Pollution Flows**: nutrient and chemical emission accounting

3. Guidance Material

¶1 Aquaculture has grown rapidly worldwide, with production exceeding wild-capture fisheries for human consumption in recent years [2]. This expansion creates accounting challenges that differ from those of traditional fisheries. Whilst wild-capture fisheries extract natural biological resources from common-pool stocks, aquaculture involves deliberate cultivation under the direct control, responsibility and management of institutional units. This placement of aquaculture within the production boundary of the national accounts carries substantial implications for how aquaculture stocks and their changes are recorded.

¶2 This Circular is foundational for **TG-6.8 Aquaculture Thematic Methods** and complements **TG-3.1 Asset Accounts**, addressing the interface between produced and non-produced assets that is particularly complex in the marine domain. The relationship between aquaculture accounting and fisheries management is addressed in **TG-1.5 OA and Fisheries Management**, which clarifies how cultivated and natural aquatic resources interact within integrated ocean accounting frameworks.

¶3 This section examines the production boundary treatment (Section 3.1), compilation procedures for aquaculture accounts (Section 3.2), asset classification for aquaculture stocks (Section 3.3), carrying capacity considerations for sustainable production (Section 3.4), and environmental interactions (Section 3.5). Section 3.6 presents worked examples demonstrating account compilation with synthetic data. The guidance presented here aligns with the SEEA Central Framework, the SEEA Agriculture, Forestry and Fisheries (SEEA AFF), and the 2025 SNA treatment of cultivated biological resources.

3.1 Production Boundary Treatment

¶1 The distinction between aquaculture and wild-capture fisheries governs their accounting treatment. The distinction rests on the **production boundary**—the demarcation between economic activity treated as production and natural processes that fall outside the production boundary [3]. For guidance on the relationship between natural and produced assets, see **TG-3.1 Asset Accounts** Section 3.4.1 (Aquatic resources) and Section 3.6 (Produced Assets in the Ocean Domain).

DRAFT

The production boundary and aquaculture

¶1 The SEEA Central Framework establishes that "the production boundary includes all activities carried out under the responsibility, control and management of a resident institutional unit in which labour and assets are used to transform inputs of goods and services into outputs of other goods and services" [4]. Applying this principle to aquatic resources, the SEEA CF states that "the growth of fish in fish farms and other aquaculture facilities is treated as a process of production" [5].

¶2 The FAO definition of aquaculture, adopted in the SEEA CF, provides the operational basis for this distinction:

> *"Aquaculture is the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms that are harvested by an individual or corporate body that has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms that are exploitable by the public as a common property resource, with or without appropriate licences, are the harvest of fisheries."* [6]

¶3 This definition establishes three criteria for treating aquatic production as aquaculture: (1) intervention in the rearing process; (2) ownership of the stock; and (3) ownership throughout the rearing

period. These criteria provide a practical basis for classification, though edge cases remain. For extensive pond culture systems with minimal intervention, or ranching programmes with delayed harvest, SEEA AFF paragraphs 2.127–2.129 provide additional guidance on distinguishing natural from cultivated processes. Where a clear institutional unit exercises control over the growth process—even if that control is limited to stocking and harvesting—the activity should be treated as aquaculture[7]. Figure 3.9.1 traces how the three criteria are applied in sequence to route an aquatic stock to one of four accounting terminals.

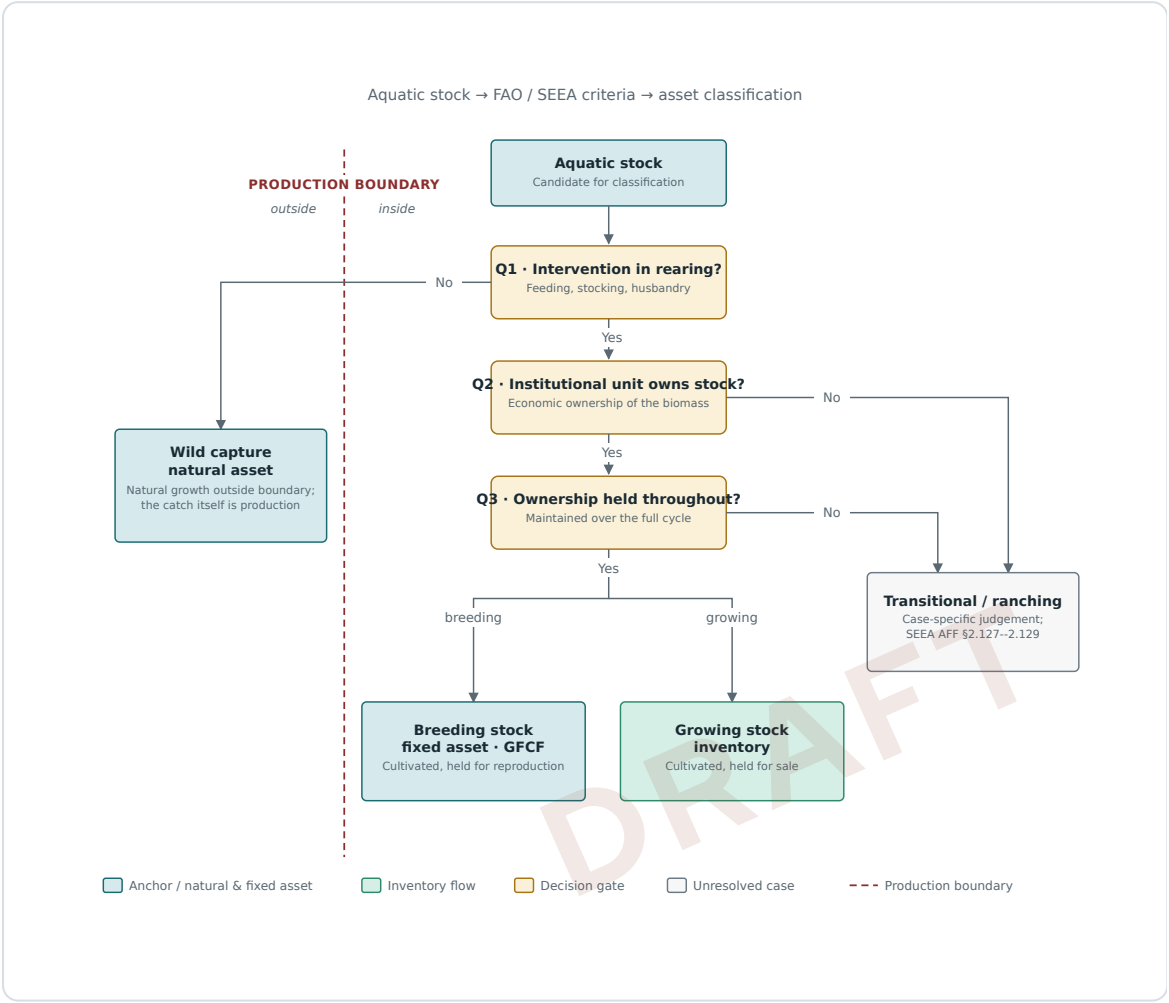


Figure 3.9.1 Three FAO/SEEA criteria route an aquatic stock to wild capture, breeding stock, growing stock, or a transitional case. Wild capture sits outside the production boundary; breeding stock is fixed capital and growing stock is inventory.

Source: TG-3.9 Section 3 (FAO / SEEA production-boundary criteria); SEEA AFF §2.127--2.129 (transitional and stock-enhancement cases).

Adapted from: SNA 2025 production-boundary treatment of cultivated biological resources and natural growth, applied to FAO aquaculture vs capture-fisheries definitions.

¶4 *Table 3.9.1: Aquaculture production boundary decision criteria*

Characteristic	Natural Aquatic Resource	Cultivated Aquatic Resource
SNA classification	Non-produced asset	Produced asset
Control over growth	No direct control	Active management
Feeding	Natural food web	Supplementary feeding
Stocking	Natural recruitment	Deliberate stocking
Harvest timing	Market/quota driven	Growth cycle driven

Characteristic	Natural Aquatic Resource	Cultivated Aquatic Resource
Asset account	Environmental asset account	Fixed asset/inventory account
Output recording	Extraction from nature	Agricultural output

¶5 This decision table summarises the distinguishing characteristics that determine whether aquatic resources fall on the natural or cultivated side of the production boundary. In practice, some operations exhibit characteristics from both columns, requiring case-by-case assessment against the three criteria established above.

Implications for accounting treatment

¶1 The placement of aquaculture within the production boundary has several implications:

¶2 **Output measurement**. The growth of aquaculture organisms constitutes **output** in the national accounts sense. This growth is recorded as production of the aquaculture industry, contributing to GDP and value added. In contrast, the natural growth of wild fish stocks is not treated as production and does not contribute directly to economic output—only the extraction (harvest) enters the economic accounts[8]. For guidance on how natural resource extraction is treated, see **TG-3.2 Flows from Environment to Economy**. The industry classification of aquaculture within the ocean economy is addressed in **TG-3.3 Economic Activity Relevant to the Ocean**.

¶3 **Asset classification**. Aquaculture stocks are classified as **produced assets** rather than natural resources. This contrasts with wild fish stocks, which are classified as natural (non-produced) assets subject to depletion accounting. The distinction between produced and non-produced assets affects balance sheet treatment and the calculation of depletion-adjusted income measures[9]. The framework for natural aquatic resource accounting is presented in **TG-3.1 Asset Accounts** Section 3.4.1.

¶4 **Capital formation**. Investment in aquaculture stocks is recorded as **gross fixed capital formation** (for breeding stocks) or **changes in inventories** (for stocks being raised for harvest). This treatment parallels the accounting for livestock in agriculture, where breeding cattle are treated as fixed assets and animals raised for slaughter are treated as inventories[10].

¶5 For mixed and transitional cases (ranching, stock enhancement, IMTA), see the reclassification guidance in Section 3.3.

DRAFT

3.2 Compilation Procedure

¶1 This section provides a step-by-step procedure for compiling aquaculture accounts, integrating production accounts, asset accounts, and environmental flow accounts. The procedure assumes that countries have established coordination mechanisms between statistical offices, aquaculture regulatory agencies, and environmental authorities as described in **TG-4.7 National Data Coordination Architectures**.

Step 1: Delineate aquaculture operations and classify systems

¶1 Identify all aquaculture operations within the national accounting boundary and classify them according to:

¶2 a) **System type**—open systems (cage culture, net-pens, on-bottom culture), closed systems (tanks, raceways, recirculating aquaculture systems), or semi-intensive systems (pond culture, integrated systems);

¶3 b) **Species or species groups**—finfish (salmon, sea bass, tuna), crustaceans (shrimp, prawns), molluscs (oysters, mussels), aquatic plants (seaweed);

¶4 c) **Salinity**—marine aquaculture (operating in coastal waters or offshore), brackish water aquaculture, or freshwater aquaculture (the latter is outside the ocean accounting boundary but may be

included in national aquaculture accounts; see the note on freshwater aquaculture scope at the end of this step);

¶5 d) **Purpose**—food production, ornamental species, stock enhancement/ranching (see Section 3.1 for treatment of transitional cases).

¶6 Data sources include aquaculture licensing registries, fisheries statistical databases (FAO FishStatJ; see **TG-4.10 Extending Fisheries Statistics** Section 3.8.1 for full database description, including coverage, refresh frequency, and limitations), remote sensing analysis for spatial extent of cage culture operations (**TG-4.1 Remote Sensing and Geospatial Data**), and industry census data from statistical offices.

¶7 **Freshwater aquaculture scope note**: Freshwater aquaculture (catfish, tilapia, carp, and other freshwater species) falls outside the ocean accounting boundary but is within scope for SNA national production accounts and should be compiled using the same methodology described in this Circular. Within ocean accounts, freshwater aquaculture production should appear as a memorandum item or in a supplementary "All Aquaculture" table that includes freshwater alongside marine and brackish production, with clear delineation by salinity category. The national total should be reconcilable to FAO FishStatJ national aquaculture production figures, which include all systems, to support cross-country comparability and external validation.

Step 2: Compile production accounts

¶1 Assemble aquaculture production data following the Supply and Use Table (SUT) framework described in **TG-3.3 Economic Activity Relevant to the Ocean**:

¶2 a) **Output**—Record aquaculture production in physical terms (tonnes live weight) and monetary terms (value at basic prices). Output includes both harvest for sale and intermediate transfers between hatcheries and grow-out operations.

¶3 b) **Intermediate consumption**—Record feed inputs (fishmeal, fish oil, plant-based feeds), fingerlings/juveniles purchased from hatcheries, veterinary services, energy inputs, and other operational inputs. Feed inputs from wild fisheries should be separately identified to enable calculation of fish-in-fish-out ratios (Section 3.5).

¶4 c) **Value added**—Calculate gross value added as output minus intermediate consumption. This measures the aquaculture sector's contribution to GDP.

¶5 d) **Employment**—Record full-time equivalent employment in aquaculture to enable productivity analysis.

¶6 Data sources include aquaculture production surveys, business censuses, industry association reports, feed sales data, and energy consumption statistics.

Step 3: Compile physical asset accounts for aquaculture stocks

¶1 Construct physical asset accounts for cultivated aquatic resources following the structure in Section 3.3 below:

¶2 a) **Opening stock**—Determine stock biomass at the beginning of the accounting period using the following tiered data source hierarchy: (1) facility biomass records as the primary source; (2) regulatory production returns where facility records are absent or unreliable; (3) statistical survey estimates where regulatory returns are unavailable; (4) model-based estimates using licensed area multiplied by species-specific average stocking density norms sourced from national fisheries authority technical tables, as a last resort. Compilers must flag fallback methods (sources 3 and 4) in metadata following **TG-0.7 Quality Assurance** conventions. For breeding stocks, record number of broodstock by species. For growing stocks, record total biomass by species and cohort/size class where data permit.

DRAFT

¶3 b) **Additions to stock**—Record natural growth (biomass increase from feeding and maturation), hatchery production or purchases of juveniles (additions to growing stocks), and reclassifications from natural resources (wild-caught organisms introduced for fattening or broodstock).

¶4 c) **Reductions in stock**—Record harvest (sales or transfers to processing), normal losses (routine mortality from disease, predation, environmental stress), catastrophic losses (disease outbreaks, harmful algal blooms, storm damage), escapes (reclassifications to natural resources), and culling (removal of unproductive broodstock).

¶5 d) **Closing stock**—Verify that closing stock equals opening stock plus additions minus reductions. Reconcile discrepancies through data quality audits.

¶6 Data sources include aquaculture facility production records, hatchery sales records, veterinary health reports, loss event reporting systems, and regulatory compliance data. For data quality considerations, see **TG-0.7 Quality Assurance**.

Step 4: Compile monetary asset accounts

¶1 Value aquaculture stocks following standard SNA principles for produced assets, applying the following method hierarchy:

¶2 a) **Inventory valuation**—Where active markets for live organisms exist and reliable price data are available, market price valuation is the preferred method, as it aligns with SNA balance sheet conventions for traded assets. Apply current market prices to biomass estimates, adjusted for size class where market prices vary by size. Revaluation entries (holding gains or losses) must be recorded separately from volume changes to avoid confounding the two in the monetary account. Where market prices are absent—for immature growth stages with no comparable market, or for species with no live trade—use the cost accumulation method described in the 2025 SNA treatment of work-in-progress (Chapter 11), recording costs incurred (feed, juveniles, labour, capital services) as inventory builds up over the growth cycle. Table 3.9.2 (monetary account columns) illustrates how revaluation entries are separated from volume changes.

¶3 b) **Breeding stock valuation**—Value breeding stocks based on expected future economic benefits from their reproductive capacity. Depreciation schedules should be based on the documented productive lifespan of the species drawn from biological literature or established industry norms. Straight-line depreciation over that productive lifespan is the default method. For operations involving mass replacement cycles—where an entire broodstock cohort is written off and replaced after a fixed number of spawning seasons (e.g., salmon broodstock replaced after 2–3 spawning cycles)—the cohort write-down and new cohort acquisition should both appear in the same accounting period as gross fixed capital formation (GFCF) and consumption of fixed capital (CFC). Market values for replacement broodstock may be used where active markets exist.

¶4 c) **Revaluations**—Record holding gains or losses reflecting price changes during the accounting period, separate from volume changes.

¶5 For valuation methodology, see **TG-3.1 Asset Accounts** Sections 3.3 (monetary asset accounts) and 3.6 (produced assets).

Step 5: Compile environmental flow accounts

¶1 Record flows between aquaculture operations and the environment following the methodology in **TG-3.2 Flows from Environment to Economy** and **TG-3.4 Flows from Economy to Environment**:

¶2 a) **Natural inputs**—Record abstraction of marine or coastal water for land-based systems (cubic metres). The following decision rule applies for water use recording: water use is recorded as abstraction when water is actively diverted from its natural course into a controlled facility, involving measurable pump intake volume. Passive water exchange through nets or tidal action in open cage culture is not abstraction and should not be recorded. Recirculating aquaculture systems (RAS) and

closed land-based systems with pump intake are clearly within scope as abstraction cases. These should be recorded following SEEA-Water definitions of abstraction[11]. Record wild fish equivalent of feed inputs as a supplementary satellite or memo item (not as a main natural input entry; see Section 3.5 and SEEA AFF para 3.169), and where quantifiable, ecosystem services supporting aquaculture (water quality maintenance, nursery habitat provision).

¶3 b) **Residual outputs**—Record nutrient emissions (nitrogen and phosphorus from uneaten feed, faeces, excretion—measured in tonnes N and P), chemical releases (therapeutants, antifoulants—kilograms active ingredient), organic waste deposition (tonnes organic matter), and escapes (number or biomass, classified by species).

¶4 c) **Spatial attribution**—Assign emissions and environmental pressures to receiving ecosystems or management zones to enable integration with ecosystem condition accounts (**TG-3.1 Asset Accounts** Section 3.5.2).

¶5 Data sources include environmental monitoring programs, aquaculture environmental impact assessments, nutrient budget models for cage culture operations, veterinary chemical use records, and escape event reporting systems. See **TG-2.7 Pollution Flows** for emission accounting methodology.

Step 6: Assess carrying capacity and sustainability indicators

¶1 Integrate aquaculture accounts with ecosystem accounts to assess sustainability:

¶2 a) **Stocking density analysis**—Compare actual stocking levels against recommended carrying capacity thresholds for different system types and species. Excessive stocking reduces growth rates, increases disease risk, and elevates environmental pressures.

¶3 b) **Feed conversion efficiency**—Calculate feed conversion ratios (FCR—mass of feed per mass of production) and fish-in-fish-out ratios (FIFO—mass of wild fish in feed per mass of farmed output) as indicators of resource efficiency. See **TG-2.11 Resource Efficiency** for indicator methodology.

¶4 c) **Environmental pressure indicators**—Calculate nutrient loading per unit area of coastal zone, sediment organic enrichment indices beneath cage sites, and chemical loading. Compare against water quality standards or ecosystem health thresholds from **TG-2.1 Biophysical Indicators**.

¶5 d) **Habitat conversion tracking**—Where aquaculture expansion involves coastal habitat conversion (mangrove clearance for pond construction, seagrass loss beneath cage moorings), record extent changes in ecosystem accounts for affected habitats. See **TG-6.2 Mangrove and Coastal Wetland Accounting** for mangrove accounting methodology.

¶6 e) **GBF Target 10 alignment**—Report area under sustainable aquaculture management regimes to track progress towards ensuring all aquaculture is under effective management that minimises impacts on biodiversity and ecosystem functions[12]. For statistical purposes, the minimum criterion for classifying an operation as "under sustainable management" is that it operates under a licence or permit that includes binding environmental performance conditions: nutrient discharge limits, escape prevention requirements, and habitat protection obligations. Third-party certified operations (e.g., ASC, BAP) constitute a subset of this definition and may be reported separately. This criterion aligns with FAO Voluntary Guidelines for Small-Scale Fisheries and CBD COP16 guidance on GBF monitoring framework implementation. It is intended as an interim operational definition pending further international agreement on Target 10 monitoring methodology.

Step 7: Integration and consistency checks

¶1 Ensure internal consistency and integration across account types:

¶2 a) **Production-asset consistency**—Verify that harvest recorded in production accounts equals reductions from harvest in asset accounts. Reconcile discrepancies through improved measurement or identification of unrecorded flows.

DRAFT

¶3 b) **Feed flow consistency**—Ensure that wild fish used for feed recorded in aquaculture intermediate consumption matches extractions recorded in fisheries accounts (**TG-1.5 OA and Fisheries Management**).

¶4 c) **Ecosystem integration**—Link aquaculture environmental pressures (nutrient loading, habitat conversion) to changes in ecosystem condition indicators for receiving ecosystems. Declining condition in coastal ecosystems may signal that aquaculture intensity exceeds ecological carrying capacity.

¶5 d) **Temporal consistency**—Maintain consistent time series by adjusting for changes in system boundaries, classification, or measurement methodology. Document adjustments in metadata following **TG-0.7 Quality Assurance** standards.

¶6 This compilation procedure provides the foundation for policy-relevant analysis. It allows governments to assess whether aquaculture expansion is sustainable, identify environmental pressure points requiring management intervention, and track progress towards blue economy and biodiversity targets.

3.3 Asset Classification

¶1 The classification of aquaculture assets must distinguish between different types of aquaculture systems and different categories of aquaculture stocks within those systems. This section builds on the general asset classification framework in **TG-3.1 Asset Accounts** Section 3.2 (Step 2).

Classification of aquaculture stocks

¶1 Within aquaculture operations, stocks must be classified according to their function in the production process:

¶2 **Breeding stocks (fixed assets)**. Aquatic organisms maintained for reproduction purposes are treated as **fixed assets** in the SNA classification[13]. These resources yield repeat products (eggs, juveniles, milt) over multiple production cycles. In asset accounts, they are recorded separately from stocks held for sale, and their growth is recorded as gross fixed capital formation. The 2025 SNA confirms that "animal resources yielding repeat products" include "aquatic resources maintained for controlled reproduction"[14].

¶3 **Growing stocks (inventories)**. Organisms being raised for eventual harvest and sale are treated as **inventories**, specifically as **work-in-progress**[15]. The growth of these organisms over the accounting period represents additions to inventory, whilst harvest represents withdrawals. The SEEA CF notes that "the majority of changes in the stock of cultivated aquatic resources should be accounted for as changes in inventories"[16].

¶4 **Hatchery output**. The treatment of hatchery production requires specific attention, and the correct recording depends on the institutional structure of the operation. For transactions between separate institutional units, juvenile organisms produced by a hatchery and sold to a grow-out operation represent output of the hatchery industry. The transaction should be recorded as a **sale and purchase of goods** (intermediate consumption by the grow-out operation), rather than as a reclassification between asset categories, since ownership changes hands through a market transaction[17]. For vertically integrated enterprises where a single institutional unit owns both the hatchery and grow-out facilities, no market transaction occurs. Intra-unit transfers are recorded as internal movements of work-in-progress inventory, with no output generated at the hatchery stage. Recording intra-unit transfers as sales would double-count output and distort gross value added estimates for the aquaculture sector. Compilers should apply the institutional unit identification approach consistent with **TG-3.3 Economic Activity Relevant to the Ocean** and the treatment of intra-enterprise transfers described in 2025 SNA Chapters 6 and 7[18].

¶5 **Integrated multi-trophic aquaculture (IMTA)**. In IMTA systems, extractive species (mussels, seaweed, sea cucumbers) are co-cultivated with fed species and derive part of their growth from

DRAFT

organic waste generated by those fed species. For asset classification purposes, extractive species in IMTA should be classified and accounted following the same cultivated biological resource framework as other aquaculture stocks (as produced assets: fixed assets or inventories depending on their function). The waste assimilation function performed by the extractive species constitutes an intra-sector ecosystem service flow, with waste from one aquaculture activity becoming a production input for another. This flow should be recorded in a supplementary physical flow account. The monetary value of the nutrient removal service may be estimated using the avoided-cost methodology described in **TG-2.4 Ecosystem Goods and Services**. The accounting treatment of IMTA is an active methodological development area. Compilers should flag IMTA entries in metadata and consult **TG-6.8 Aquaculture Thematic Methods** for further guidance as it becomes available.

¶6 **Ornamental aquaculture**. Ornamental species (marine fish, corals, live rock) classified under purpose category (d) in Step 1 are within scope for aquaculture accounts and should be compiled using the same cultivated biological resource framework. The specific data challenge for ornamentals is that production is not recorded in FAO FishStatJ food production databases, which cover food and feed species. Compilers should use national licensing registries and trade data (import/export statistics for live ornamental species) as primary data sources. The production boundary criterion applies in full: cultivated classification requires ownership and control throughout the rearing period. Wild-caught marine organisms held temporarily for resale do not qualify as aquaculture and should not be included in cultivated asset accounts (the ownership-throughout-rearing criterion in SEEA CF para 5.409 is not satisfied) and their extraction is therefore recorded under natural resource use per SEEA CF para 5.407[19].

Physical asset account structure

¶1 Table 3.9.2 presents the structure of a physical asset account for cultivated aquatic resources, following the format in SEEA CF Table 5.22.

¶2 *Table 3.9.2: Structure of physical asset account for cultivated aquatic resources*

Accounting entry	Breeding stocks (fixed assets)	Growing stocks (inventories)	Total cultivated
Opening stock	Number/tonnes	Tonnes	Tonnes
Additions to stock			
– Growth in stock	Natural increase	Biomass gain	
– Purchases/hatchery production	Broodstock acquisitions	Juvenile stocking	
– Reclassifications (from natural)	Wild-caught broodstock	Wild-caught for fattening	
Total additions			
Reductions in stock			
– Harvest	–	Sales/processing	
– Normal losses	Routine mortality	Routine mortality	
– Catastrophic losses	Disease/environmental events	Disease/environmental events	
– Culling	Unproductive broodstock	–	
– Reclassifications (to natural)	–	Escapes/releases	
Total reductions			
Closing stock	Number/tonnes	Tonnes	Tonnes

¶3 **Note on monetary account columns**: Where monetary columns are added to Table 3.9.2, revaluation entries (holding gains/losses from price changes) must be presented as a separate line

DRAFT

item distinct from the volume change entries above, to avoid confounding volume and price effects in the time series. See Step 4 for the method hierarchy governing monetary valuation.

¶4 **Note on breeding stock depreciation illustration**: For a cohort replaced after two spawning cycles (typically two years for Atlantic salmon), a compiler would record in Year 1: GFCF for the new cohort acquisition; in Year 2: CFC (consumption of fixed capital) through the year as productive capacity declines, and at end of Year 2: the remaining book value written down simultaneously with new cohort GFCF. Both entries appear in the same accounting period when mass replacement occurs.

¶5 This structure parallels the asset account for natural aquatic resources presented in **TG-3.1 Asset Accounts** Table 1, enabling side-by-side comparison and consolidation of total aquatic resource accounts.

¶6 **Growth in stock** encompasses both increase in numbers (through hatching, natural reproduction where relevant) and increase in biomass (growth of individual organisms). For breeding stocks, only the growth of the breeding population is recorded. The juveniles produced are recorded as additions to growing stocks.

¶7 **Reclassifications** record transfers between natural and cultivated categories. Introduction of wild-caught organisms as broodstock or seed represents a reclassification from natural to cultivated resources. Release of cultured organisms for ranching or enhancement programmes, and escapes from aquaculture facilities, represent reclassifications from cultivated to natural resources [20].

¶8 **Harvest** records the removal of organisms from growing stocks for sale or processing. For breeding stocks, animals removed for slaughter (culling of unproductive or excess broodstock) are recorded as reductions.

¶9 **Normal losses** include mortality from routine causes such as disease, predation, and environmental stress within normal operating parameters.

¶10 **Catastrophic losses** record exceptional losses from disease outbreaks, harmful algal blooms, extreme weather events, or other unexpected events beyond normal operating expectations [21].

DRAFT

Monetary valuation

¶1 Aquaculture stocks are valued following standard SNA principles for produced assets. For inventory valuation, the 2025 SNA treatment of work-in-progress recognises that cost accumulation methods may not provide satisfactory results where growth is non-linear [22]. Similar challenges arise for aquaculture, where growth is not linear and substantial mortality may occur. For guidance on valuation approaches, see **TG-1.9 Valuation**.

¶2 For breeding stocks (fixed assets), valuation should reflect the expected future economic benefits from the breeding capacity. Depreciation is recorded for the decline in value as breeding animals age and their productive capacity declines [23].

3.4 Carrying Capacity Considerations

¶1 Aquaculture production occurs within environmental constraints that determine the sustainable level of production. Accounting for these constraints supports assessment of the long-term viability of aquaculture operations and their interactions with marine ecosystems.

Concept of carrying capacity in aquaculture

¶1 The concept of **carrying capacity** in aquaculture contexts refers to the maximum production that can be sustained in a given environment without causing unacceptable environmental impacts or production failures. The FAO definition of aquaculture (see footnote [6]) describes aquaculture as involving “some form of intervention in the rearing process to enhance production,” whilst ISIC

Rev.4 Group 032 describes aquaculture as involving "some form of intervention in the rearing process... Farming also implies individual or corporate ownership of the stock being cultivated" [24].

¶2 Drawing on aquaculture science literature and applying the carrying capacity concept recognized in SEEA AFF para 3.90, several dimensions of carrying capacity are relevant for accounting purposes. Table 3.4.1 below summarises these dimensions.

Dimension	Description
Physical carrying capacity	The maximum stocking density or production that can be achieved given physical and biological constraints (space, oxygen, water flow, etc.).
Production carrying capacity	The level of production at which marginal costs equal marginal revenues — the economically optimal production level given input costs and output prices.
Ecological carrying capacity	The level of production that can be sustained without causing unacceptable impacts on the surrounding environment or wild populations. Particularly relevant for open aquaculture systems that interact with marine ecosystems.
Social carrying capacity	The level of production that is acceptable given competing uses of coastal and marine space and community concerns about environmental and aesthetic impacts.

¶3 The Statistical Framework for Measuring the Sustainability of Tourism (SF-MST) provides a parallel treatment of carrying capacity in its discussion of tourism environmental limits (para 4.103), supporting the broader applicability of carrying capacity concepts within environmental-economic accounting [25]. The SEEA AFF notes that asset accounts "can be used to better understand the carrying capacity of agricultural areas with respect to livestock, for example, the number of cattle per hectare" [26]. This is a direct statistical precedent for applying carrying capacity analysis to cultivated biological resources.

Authoritative sources for carrying capacity thresholds

¶1 For statistical compilation purposes, national statistical offices (NSOs) should adopt carrying capacity thresholds published by national competent authorities (principally aquaculture licensing agencies and environmental regulators) where such thresholds have been formally established. These published regulatory thresholds provide the most replicable and institutionally consistent basis for the sustainability assessments in Step 6. Where no national thresholds exist, NSOs should use FAO Technical Guidelines for Responsible Fisheries No. 5 (Aquaculture Development) or peer-reviewed species-specific benchmarks from the scientific literature as reference values, flagging these as provisional in metadata consistent with **TG-0.7 Quality Assurance** conventions. The NSO's role is to compile and report against established thresholds, not to derive or adjudicate carrying capacity values independently. For thematic methodological detail on carrying capacity assessment methods, see **TG-6.8 Aquaculture Thematic Methods**.

Accounting implications

¶1 For accounting purposes, carrying capacity considerations affect the interpretation of production levels and the assessment of sustainability:

¶2 **Stock assessment**. The opening and closing stocks of cultivated aquatic resources should be assessed against the carrying capacity of the facilities and environment. Stocking at levels that exceed carrying capacity may lead to reduced growth rates, increased mortality, disease outbreaks, and environmental degradation.

¶3 **Sustainable yield**. Whilst the concept of maximum sustainable yield (MSY) is traditionally applied to wild fisheries (see **TG-6.7 Fisheries Stock Assessment**), analogous concepts apply to aquaculture in open systems. Production that exceeds ecological carrying capacity may degrade the supporting ecosystem, reducing its capacity to support future production.

DRAFT

¶4 **Environmental condition**. For open aquaculture systems operating within marine ecosystems, the ecosystem condition accounts described in **TG-3.1 Asset Accounts** Section 3.5.2 should capture changes in environmental quality that affect or are affected by aquaculture operations.

Integration with ecosystem accounts

¶1 The SEEA Ecosystem Accounting framework provides a basis for linking aquaculture accounts with ecosystem condition and service accounts. Key linkages include:

¶2 **Supporting services**. Marine ecosystems provide water quality maintenance, waste assimilation, and habitat functions that support aquaculture production. Degradation of these supporting services may reduce carrying capacity and production potential.

¶3 **Provisioning services**. In some extensive aquaculture systems, natural productivity contributes directly to fish growth, representing a flow of ecosystem services to the aquaculture activity.

¶4 **Regulating services**. Ecosystems regulate water temperature, disease prevalence, and harmful algal blooms, all of which affect aquaculture production.

¶5 For guidance on ecosystem service accounting, see **TG-3.2 Flows from Environment to Economy** and **TG-2.4 Ecosystem Goods and Services**.

3.5 Environmental Interactions

¶1 Aquaculture, particularly in open marine systems, interacts substantially with the surrounding environment. These interactions must be captured in ocean accounts to record the aquaculture sector's environmental dependencies and impacts in full. This section complements the general guidance on environmental flows in **TG-3.2 Flows from Environment to Economy** and **TG-3.4 Flows from Economy to Environment**.

Inputs from the environment

¶1 Aquaculture operations draw upon environmental inputs that should be recorded in physical supply and use accounts:

¶2 **Water abstraction**. Land-based aquaculture systems (tanks, ponds, raceways) may abstract large volumes of freshwater or seawater. These abstractions should be recorded in water accounts following the methodology in SEEA-Water [11]. For marine cage culture, passive water exchange through nets or tidal action is not abstraction and should not be recorded. Only pumped intake into a controlled facility qualifies (see the decision rule in Step 5a). Water quality requirements for cage culture operations should be noted as context for ecosystem condition assessment.

¶3 **Feed from wild fisheries**. A material environmental interaction is the use of fish meal and fish oil derived from wild-caught fish as feed inputs for carnivorous aquaculture species [27]. The SEEA AFF notes that "fish products provide nutrition in a stable and concentrated form, which enables the fish to feed efficiently and grow to their full potential. Many of the intensively farmed fish are carnivorous, including, among others, Atlantic salmon, trout, sea bass and turbot. In line with the emergence of modern aquaculture in the 1970s, fish meal and fish oil have become major components of feed for those species" [28].

¶4 The relationship between aquaculture feed and wild fish stocks requires careful treatment to avoid double-counting in linked accounts. In most commercial operations, aquaculture operators purchase commercially processed fishmeal and fish oil as intermediate inputs, not raw wild fish directly. The wild fish extraction that generates this fishmeal is already recorded in the fisheries supply account at the point of harvest. Compilers should not record the fishmeal content of purchased feed as a separate "natural input" in the aquaculture accounts, as this would double-count the same fish stock depletion. Commercially purchased fishmeal and fish oil appear in the supply and use table as purchased goods (intermediate consumption by the aquaculture industry), not as direct flows from nature [29]. The analytical relationship between fishmeal use and wild fish extraction is

DRAFT

captured by the **fish-in-fish-out ratio** (FIFO)—the ratio of wild fish equivalent embedded in feed per unit of farmed output produced. This is an analytical indicator rather than a separate accounting entry. Where NSOs wish to show the wild fish equivalent of purchased feed, it should be presented as a supplementary satellite table or memo item, aligned with SEEA AFF para 3.169. The **feed conversion ratio** (FCR)—the ratio of feed input to fish output—is a key efficiency indicator and should be reported alongside FIFO in resource efficiency analysis. FIFO ratios vary substantially by species and have been declining over time with improvements in feed technology and partial replacement of fishmeal by plant-based proteins [30]. For supply and use accounting, the feed inputs (measured in tonnes) should be recorded as intermediate consumption. For resource efficiency analysis, see **TG-2.11 Resource Efficiency**.

¶5 **Ecosystem services**. As noted in Section 3.4, aquaculture benefits from ecosystem services including water quality maintenance, disease regulation, and larval supply (for some species). These services represent flows from the environment to the economy that may be captured in ecosystem service accounts.

Outputs to the environment

¶1 Aquaculture operations generate outputs to the environment that should be recorded in residual flow accounts:

¶2 **Nutrient loading**. Aquaculture releases nutrients (primarily nitrogen and phosphorus) through uneaten feed, faeces, and metabolic excretion. In open systems, these nutrients are released directly to the marine environment and may contribute to eutrophication in poorly flushed areas [31]. Nutrient releases should be recorded in emission accounts following the SEEA CF methodology for residual flows. For guidance on pollution flow accounting, see **TG-2.7 Pollution Flows**.

¶3 **Organic matter**. Feed waste and faeces settling beneath cage sites can alter benthic conditions, affecting sediment chemistry and benthic communities.

¶4 **Chemical releases**. Aquaculture may involve use of therapeutants (antibiotics, parasiticides), antifoulants, and other chemicals that are released to the environment. These should be recorded following standard emission accounting principles. Chemical treatments for parasites (e.g., hydrogen peroxide, azamethiphos) are quantifiable where veterinary chemical use records are maintained and should appear in the chemical releases row with a species/compound breakdown where data permit.

¶5 **Escapes**. Organisms that escape from aquaculture facilities represent a flow from the economy to the environment. As noted in Sections 3.1 and 3.3 (Table 3.9.2), these should be recorded as reclassifications from cultivated to natural aquatic resources "in cases where the fish are able to integrate into natural fish stocks" [32]. Where integration is not possible (e.g., non-native species in unsuitable environments), escapes should be recorded as losses.

¶6 **Pathogen and parasite pressure**. Aquaculture operations may transmit pathogens and parasites to wild populations, an interaction with documented ecosystem condition effects. Where quantification is possible (for example, sea lice counts per fish from regulatory reporting in salmon-producing countries, or volumes of antiparasitic chemicals used), these should be recorded in ecosystem condition accounts as pressure indicators linked to **TG-2.1 Biophysical Indicators**. Quantifiable chemical treatments (e.g., antiparasitic compound volumes) should appear in the chemical releases row of Table 3.9.3 with a species/compound breakdown. The transmission of biological parasites or pathogens to wild populations is not currently quantifiable within standard SEEA accounting structures and is flagged as a methodological development area for future revision.

Recording environmental interactions

¶1 Table 3.9.3 presents a framework for recording the principal environmental interactions of aquaculture in physical terms.

DRAFT

¶2 *Table 3.9.3: Framework for recording environmental interactions of aquaculture*

Flow type	Category	Measurement unit	Relevant account	Cross-reference
Inputs				
Water abstraction	Natural input	Cubic metres	Water accounts	TG-3.2
Wild fish for feed (memo item)	Supplementary	Tonnes wild fish equivalent	Satellite/memo table	TG-3.2
Ecosystem services	Service flow	Various	Ecosystem service accounts	TG-2.4
Outputs				
Nutrient releases (N, P)	Residual	Tonnes	Emission accounts	TG-3.4, TG-2.7
Chemical releases (incl. antiparasitics)	Residual	Kilograms	Emission accounts	TG-3.4
Organic waste	Residual	Tonnes	Waste accounts	TG-3.4
Escapes	Reclassification	Number/tonnes	Asset accounts	TG-3.1
Pathogen/parasite pressure	Ecosystem condition indicator	Various (lice counts, chemical volumes)	Ecosystem condition accounts	TG-3.1 Section 3.5.2

Integration with flows accounts

¶1 The environmental interactions of aquaculture should be integrated with the flow accounts described in **TG-3.2 Flows from Environment to Economy** and **TG-3.4 Flows from Economy to Environment**. This integration enables:

- ¶2 Calculation of resource efficiency indicators (e.g., water use per tonne of production, feed conversion ratios)—see **TG-2.11 Resource Efficiency**
- ¶3 Assessment of environmental pressures relative to ecosystem carrying capacity
- ¶4 Linking of aquaculture activity to changes in ecosystem condition—see **TG-2.1 Biophysical Indicators**
- ¶5 Derivation of sustainability indicators for aquaculture management

¶6 For detailed methodological guidance on site-specific assessment and integration with ecosystem accounts, see **TG-6.8 Aquaculture Thematic Methods**. The broader relationship between aquaculture and fisheries within ocean accounting is addressed in **TG-1.5 OA and Fisheries Management**, which discusses how aquaculture and wild-capture fisheries interact in contributing to ocean-based food production and how both are treated within integrated fisheries governance frameworks.

3.6 Worked Examples

¶1 This section presents three worked examples with synthetic data demonstrating the compilation of aquaculture accounts for common scenarios: a shrimp farm production account, a coastal zone mangrove conversion tracking system, and a salmon cage culture nutrient loading assessment.

Example 1: Coastal shrimp farm production and asset accounts

¶1 **Context**: A coastal nation operates intensive shrimp aquaculture in converted mangrove areas. The example demonstrates production account compilation, asset account structure for growing stocks, and feed flow tracking.

DRAFT

¶2 **Scenario parameters** (synthetic data for accounting year 2025):

- ¶3 Total shrimp farm area: 500 hectares
- ¶4 Growing stocks opening biomass: 800 tonnes
- ¶5 Stocking during year: 1,200 tonnes of juveniles at nursery stocking size (assumed average individual weight: 0.3 g, equivalent to approximately 4.0 billion individuals. This refers to post-larvae at PL20 or larger nursery stage, not newly hatched post-larvae)[33]
- ¶6 Biomass growth: 3,500 tonnes (from feeding and maturation)
- ¶7 Harvest: 3,800 tonnes (market-size shrimp)
- ¶8 Normal losses: 600 tonnes (mortality from disease, predation)
- ¶9 Catastrophic losses: 100 tonnes (disease outbreak in one farm cluster)
- ¶10 Closing biomass: 1,000 tonnes
- ¶11 Feed inputs: 6,000 tonnes commercial feed (25% fishmeal content = 1,500 tonnes fishmeal from wild fisheries)
- ¶12 Production value: USD 38 million at basic prices
- ¶13 Intermediate consumption: USD 22 million (feed USD 15 million, PL USD 3 million, other USD 4 million)
- ¶14 Value added: USD 16 million

¶15 *Table 3.9.4: Shrimp aquaculture physical asset account, 2025*

Accounting entry	Growing stocks (tonnes live weight)	Growing stocks (millions of individuals – memo)
Opening stock	800	–
Additions to stock		
– Growth in stock	3,500	–
– Purchases (PL stocking)	1,200	4,000
– Reclassifications (from natural)	0	0
Total additions	4,700	
Reductions in stock		
– Harvest	3,800	–
– Normal losses	600	–
– Catastrophic losses	100	–
– Reclassifications (to natural)	0	0
Total reductions	4,500	
Closing stock	1,000	–

DRAFT

¶16 **Note on PL stocking unit**: Post-larvae (PL) are commercially traded in millions of individuals. The 1,200 tonnes figure represents nursery-stage juveniles at approximately 0.3 g average body weight (approximately 4,000 million individuals or 4.0 billion PL). Where the primary data source is in units of millions of individuals, compilers should convert to biomass using the average individual weight at stocking, which should be documented in facility records or species-specific industry norms. The memo column above illustrates this parallel recording.

¶17 **Verification**: Closing stock (1,000) = Opening stock (800) + Additions (4,700) - Reductions (4,500). Account balances correctly.

¶18 **Feed conversion and efficiency indicators**:

- ¶19 Feed conversion ratio (FCR) = Feed input / Biomass growth = 6,000 / 3,500 = 1.71 (industry benchmark for intensive shrimp: 1.5-2.0)

- ¶20 Fish-in-fish-out ratio (FIFO) = Wild fish equivalent of fishmeal / Harvest = (1,500 / 0.225) / 3,800 = 6,667 / 3,800 = 1.75, at the standard fishmeal yield of 22.5 per cent of raw fish[34] (net consumer of wild fish, as FIFO > 1.0)

> ¶21 **Corrected 24 September 2026**
> ¶22 FIFO was previously computed as fishmeal ÷ harvest (0.39, "net contributor"); on the circular's own definition it is wild fish equivalent ÷ farmed output, which at a 22.5 per cent fishmeal yield is 1.75, so the farm is a net consumer of wild fish. FCR is now computed on biomass growth (production), as defined in Section 3.2, Step 6.

¶23 **Production account linkages**: The 3,800 tonnes harvest recorded as reduction in asset account should match output recorded in supply table for ISIC 0321 (Marine aquaculture). The USD 3 million PL purchases appear as intermediate consumption in the shrimp farm production account and as output in the hatchery industry production account.

¶24 **Environmental flow implications**: The 1,500 tonnes of fishmeal embodied in purchased feed, about 6,700 tonnes of wild fish equivalent, represents a wild fish equivalent analytical indicator (FIFO). This should be presented as a satellite table or memo item rather than as a direct natural input in the main accounts, consistent with the double-counting avoidance rule described in Section 3.5 and SEEA AFF para 3.169.

Example 2: Mangrove conversion tracking for shrimp pond expansion

¶1 **Context**: The same coastal nation experienced shrimp aquaculture expansion from 2020-2025, involving conversion of mangrove ecosystems to pond culture. The example demonstrates integration of aquaculture asset accounts with ecosystem extent accounts.

¶2 **Scenario parameters** (synthetic data):

- ¶3 Mangrove extent 2020: 12,000 hectares
- ¶4 Mangrove extent 2025: 11,500 hectares
- ¶5 Shrimp pond extent 2020: 300 hectares
- ¶6 Shrimp pond extent 2025: 500 hectares
- ¶7 Documented mangrove-to-pond conversion 2020-2025: 200 hectares
- ¶8 Other mangrove losses (erosion, development): 300 hectares

¶9 *Table 3.9.5: Ecosystem extent account for mangrove and shrimp pond ecosystems, 2020-2025*

Accounting entry	Mangrove (hectares)	Shrimp pond (hectares)
Opening extent (2020)	12,000	300
Extent additions		
– Managed expansion	0	200
– Natural regeneration	0	0
Total additions	0	200
Extent reductions		
– Conversion to aquaculture	200	0
– Conversion to other uses	300	0
– Coastal erosion	0	0
Total reductions	500	0
Closing extent (2025)	11,500	500

¶10 **Cross-account consistency**: The 200 hectares of mangrove-to-pond conversion appears as a reduction in the mangrove extent account and as an addition to the shrimp pond (produced asset) area. This reclassification tracks the transformation of natural ecosystem assets into cultivated aquaculture infrastructure.

DRAFT

¶11 **Policy implications**: The 4.2% loss of mangrove extent over five years signals environmental pressure from aquaculture expansion. Mangrove ecosystem service losses include carbon sequestration capacity (estimated 3-5 tonnes CO2e/ha/yr), coastal protection value, and nursery habitat for wild fisheries. See **TG-6.2 Mangrove and Coastal Wetland Accounting** for mangrove accounting methodology, including valuation of ecosystem services lost through conversion.

¶12 **GBF Target 10 relevance**: Countries reporting under the Kunming-Montreal Global Biodiversity Framework must track area under sustainable aquaculture. The 200-hectare mangrove conversion would need to be balanced by demonstrating that the resulting shrimp farms meet environmental sustainability criteria to avoid negative reporting against biodiversity targets.

Example 3: Salmon cage culture nutrient loading to coastal ecosystem

¶1 **Context**: A temperate coastal nation operates salmon cage culture in fjords and sheltered coastal waters. The example demonstrates compilation of nutrient emission accounts and integration with ecosystem condition assessment.

¶2 **Scenario parameters** (synthetic data for accounting year 2025):

- ¶3 Salmon production: 150,000 tonnes live weight harvest
- ¶4 Feed input: 195,000 tonnes (FCR = 1.3)
- ¶5 Feed composition: 30% protein, 20% fat, nitrogen content 4.8% of feed, phosphorus content 0.9%
- ¶6 Estimated nutrient releases applying **illustrative** release fractions (see note below):
  - ¶7 Nitrogen: 195,000 tonnes feed × 0.048 × 0.65 (illustrative N release fraction) = 6,084 tonnes N
  - ¶8 Phosphorus: 195,000 tonnes feed × 0.009 × 0.70 (illustrative P release fraction) = 1,229 tonnes P
- ¶9 Receiving coastal ecosystems: 15 fjord systems, total surface area 450 km²

¶10 **Note on release fractions**: The nitrogen (0.65) and phosphorus (0.70) release fractions used in this example are illustrative scenario parameters, not authoritative emission factors. They fall within the upper range of published values for intensive fed-finfish systems. Compilers should use release fractions from their national regulatory framework, environmental monitoring programmes, or established reference sources (e.g., HELCOM PLC-Water Guidelines, which specify aquaculture nutrient thresholds for the Baltic Sea, or FAO reference values [35]). Published release fractions vary by feed composition, species, and production system type. Table 3.9.6 illustrates this range:

¶11 *Table 3.9.6: Published range of nutrient release fractions by aquaculture system type (illustrative)*

System type	N release fraction (range)	P release fraction (range)	Source basis
Intensive fed finfish (cage)	0.55–0.75	0.60–0.75	Holmer (2010) [31] ; HELCOM
Semi-intensive pond	0.30–0.55	0.40–0.60	Literature range
Recirculating aquaculture (RAS)	0.10–0.30	0.15–0.35	Technology-dependent

¶12 *Table 3.9.7: Nutrient emission account for salmon aquaculture, 2025*

Residual type	Measurement unit	Quantity	Receiving ecosystem	Relevant standard
Nitrogen (N)	Tonnes N	6,084	Fjord coastal waters	SEEA CF Table 3.2
Phosphorus (P)	Tonnes P	1,229	Fjord coastal waters	SEEA CF Table 3.2

¶13 **Nutrient loading intensity**:

DRAFT

- ¶14 Nitrogen loading = 6,084 tonnes / 450 km² = 13.5 tonnes N/km²/yr
- ¶15 Phosphorus loading = 1,229 tonnes / 450 km² = 2.7 tonnes P/km²/yr

¶16 **Ecosystem condition linkages**: These nutrient loading rates should be assessed against water quality standards and ecosystem condition indicators from **TG-2.1 Biophysical Indicators**. Indicators might include:

- ¶17 Dissolved oxygen levels in bottom waters (hypoxia threshold: < 2 mg/L)
- ¶18 Chlorophyll-a concentrations (eutrophication indicator)
- ¶19 Benthic community condition indices beneath cage sites

¶20 **Carrying capacity assessment**: If condition indicators show declining trends (increasing hypoxia, benthic degradation), this signals that aquaculture intensity may exceed the ecological carrying capacity of the receiving fjord systems. Authorities may need to adjust licensing to reduce stocking density or redistribute farms to less-impacted areas.

¶21 **Data sources**: Nutrient release estimates are typically derived from mass-balance models combining feed input data (from industry records), feed composition (from nutritional analysis), and empirically-determined release fractions (from scientific literature or site-specific monitoring). For emission accounting methodology, see **TG-2.7 Pollution Flows** and **TG-3.4 Flows from Economy to Environment**.

¶22 **Cross-stack connections**: These worked examples demonstrate integration across the accounting stack:

- ¶23 **Upward to TG-1.x policy**: Mangrove conversion and nutrient loading evidence informs decisions on aquaculture zoning, licensing thresholds, and environmental performance standards (**TG-1.2 OA and Marine Spatial Planning**, **TG-1.5 OA and Fisheries Management**).
- ¶24 **Lateral to TG-2.x indicators**: FCR and FIFO ratios feed into resource efficiency indicators (**TG-2.11**), and nutrient loading drives water quality indicators (**TG-2.1**).
- ¶25 **Downward to TG-4.x data**: Extent mapping requires remote sensing and geospatial analysis (**TG-4.1**). Nutrient budget models require data integration from production statistics, feed composition databases, and field monitoring (**TG-4.6 Data Harmonisation and Interoperability**).

DRAFT

3.7 Provisioning-Service Quantification: Linking Aquaculture Output to Ecosystem Service Accounts

¶1 Aquaculture production accounts (Sections 3.2–3.3) measure cultivated output as a produced asset within the SNA production boundary. They do not, by themselves, quantify the **provisioning ecosystem services** that supporting marine and coastal ecosystems contribute to that output, nor do they quantify the wild-capture and gleaning flows that often coexist with aquaculture in the same coastal zone. Practitioners may consider compiling complementary provisioning-service accounts following SEEA EA Chapter 6, particularly where aquaculture sits alongside wild-capture fisheries, gleaning, or mangrove fuel-wood collection in an integrated coastal accounting area [36].

¶2 The candidate workflows below are presented as parallel quantification pipelines: aquaculture production accounting (covered in Sections 3.2–3.3), wild-capture catch accounting, gleaning, and wood/non-timber forest product (NTFP) provisioning. Each pipeline produces a physical supply table and, where feasible, a monetary supply table. Practitioners may select the workflows applicable to their accounting area and tier their implementation according to data availability.

3.7.1 Aquaculture production accounting (reference)

¶1 The physical asset and production accounts compiled per Sections 3.2–3.3 directly populate the provisioning-service entry for cultivated aquatic resources. Output recorded in tonnes live weight by species and system type may be cross-tabulated against the supporting ecosystem (coastal waters, brackish ponds converted from mangrove, offshore cage sites) to indicate the

spatial distribution of cultivated provisioning supply. Monetary valuation follows the produced-asset method hierarchy in Step 4 (market price; cost-accumulation fallback). FAO aquaculture statistics, reported through FAO FishStatJ, provide the national benchmark against which compiled accounts may be reconciled [37].

3.7.2 Wild-capture catch accounting (parallel workflow)

¶1 Wild-capture fisheries operating in the same coastal zone as aquaculture should be accounted as a distinct provisioning service flow drawn from natural (non-produced) aquatic resources. Practitioners may consider the following candidate pipeline, adapted from SEEA EA Section 6.1:

¶2 a) **Physical measurement.** Compile total annual landed catch (kg/yr) from national or regional fisheries agency records, supplemented where coverage is thin by structured fisher surveys. Disaggregate by (i) species or species group; (ii) gear type; and (iii) ecosystem association (typically coral reef, seagrass, mangrove, or pelagic) using species-habitat associations from peer-reviewed literature, validated against local fisher knowledge where feasible. Where landing surveys cover only a fraction of trips, practitioners may calibrate coverage against provincial or regional statistics to derive an extrapolation factor.

¶3 b) **Monetary valuation: resource rent.** Resource rent is computed following the method defined in **TG-3.2 Flows from Environment to Economy** Section 3.5. A negative residual indicates that fishing costs exceed revenue under prevailing conditions and may be reported as a zero ecosystem service value with the negative figure disclosed in metadata. The resource rent method is consistent with the FAO Code of Conduct for Responsible Fisheries principles on economic sustainability of fisheries [38] and with the SEEA EA treatment of market-based provisioning services [39].

¶4 c) **Tiered implementation.** Practitioners may begin at Tier 1 (national aggregate catch statistics with global or regional unit values transferred from comparable contexts) and progress to Tier 2 (locally compiled landings disaggregated by species, gear, and ecosystem, with domestically sourced cost data) or Tier 3 (vessel-level production accounts with site-specific capital stock valuation). Value-transfer accuracy is limited and may not be acceptable beyond preliminary accounts. Practitioners may consider flagging Tier 1 entries as indicative.

¶5 d) **Data sources.** FAO FishStat global capture production records provide the international benchmark [40]. National fisheries authority landings registers, port samplers, and structured artisanal-fisher surveys provide the disaggregated detail required for ecosystem attribution.

3.7.3 Gleaning (intertidal hand-collection)

¶1 Gleaning (the hand-collection of molluscs, crustaceans, echinoderms, and seaweeds from intertidal mudflats, reef flats, and mangrove edges) is a provisioning flow often missed by both aquaculture and conventional fisheries statistics, despite its importance for coastal household food security and women's livelihoods. Practitioners may consider a parallel candidate workflow:

¶2 a) **Physical measurement.** Where direct catch records are unavailable, household survey instruments may be used to estimate per-collector annual harvest (kg/yr) by target species group. Aggregate across the eligible population within accessible distance of the providing ecosystem. Spatial proxy models — in which collection is modelled as a function of distance to the resource edge, accessible standing stock, and household demand parameters — may be used to extrapolate where survey coverage is incomplete.

¶3 b) **Monetary valuation.** Where gleaned products enter local markets, first-sale prices may be used to compute gross revenue and a resource rent computed analogously to wild-capture fisheries (Section 3.7.2). Where collection is predominantly for subsistence with no observed market transaction, practitioners may consider a substitute-cost approach — valuing the catch against the market price of the nearest commercial equivalent — and recording the result as a Category V (non-market) valuation in metadata.

DRAFT

¶4 c) **Use table.** Gleaning output typically flows to subsistence households rather than the formal fisheries sector. The use table should record this allocation distinctly to preserve the distributional information needed for livelihood and food-security analysis.

3.7.4 Wood and non-timber forest product (NTFP) provisioning from mangroves

¶1 Where aquaculture operations are sited in or adjacent to mangrove ecosystems — a common pattern for brackish-water shrimp and milkfish ponds — the mangrove area that remains intact may continue to provide wood and NTFP provisioning services (fuel wood, building poles, charcoal feedstock, honey, dye, traditional medicine) to surrounding communities. The provisioning-service account for mangrove wood is conceptually independent from the aquaculture account but should be compiled in the same accounting area to enable trade-off analysis between mangrove conversion for ponds and retained mangrove provisioning value.

¶2 a) **Physical measurement.** Where direct household survey data on fuel-wood collection are unavailable, practitioners may consider a spatial proxy model estimating per-household extraction as a function of distance from household to mangrove edge, accessible deadwood stock, and a baseline household demand parameter drawn from peer-reviewed literature. Aggregation across eligible households within an accessible distance band yields total annual collection. Practitioners may flag the use rate against a sustainable yield benchmark (commonly expressed as a function of standing biomass and rotation length) to check consistency with mangrove extent accounts.

¶3 b) **Monetary valuation — substitute-cost.** Where collected wood does not enter formal markets, the candidate primary method is substitute-cost: total annual collection converted to energy equivalent and valued at the market price of the displaced commercial fuel (typically LPG or kerosene). Air-dried biomass is converted to MJ using species-appropriate calorific values. Bark and leaves are typically excluded.

¶4 c) **Monetary valuation — resource rent (stumpage value).** Where mangrove wood is marketed (sold as timber, poles, or firewood), practitioners may instead use the stumpage-value resource rent method: market price at point of sale less harvesting and transport costs. This yields a directly observed market-based exchange value consistent with SEEA EA monetary valuation hierarchy[41].

¶5 d) **Cross-account consistency.** The use rate implied by the physical account must be cross-checked against extent and condition accounts for the providing mangrove ecosystem. A use rate exceeding sustainable yield implies declining mangrove biomass, and that decline should be reflected in the extent or condition account and metadata. Practitioners may consider flagging districts where mangroves have been substantially converted to aquaculture as excluded from the provisioning model.

3.7.5 Data quality and limitations

¶1 Provisioning-service quantification in coastal contexts is sensitive to several recurring data-quality issues that practitioners may consider documenting in account metadata:

- ¶2 Limited cost-survey data or low response rates in artisanal contexts may yield unreliable resource rent estimates. Practitioners may consider increasing survey effort, supplementing with focus groups, or flagging the entry as data-deficient.
- ¶3 Subsistence catch and gleaning are difficult to value at market prices. Recording them separately, with a noted data gap, preserves the physical signal.
- ¶4 Species-habitat allocations drawn from regional literature may not reflect local ecological conditions and may require validation with local fishers.
- ¶5 Spatial proxy models for wood and NTFP provisioning are sensitive to literature-derived distance elasticity and use-rate parameters. Sensitivity analysis on these parameters is good practice.
- ¶6 Charcoal and processed-product value streams may be material but are often excluded from primary proxy models. Practitioners may consider supplementary accounts for these flows.

DRAFT

¶7 This subsection presents candidate workflows. Practitioners may select among them according to the structure of the accounting area, the data available, and the policy questions the account is intended to support. The SEEA EA framework permits parallel compilation of cultivated and natural provisioning accounts in a single physical supply and use table, with monetary entries compiled where data permit[42].

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

¶3 **Note:** This circular addresses a priority addition identified in the February 2025 modular structure revision.

5. References

1. ¶1 FAO (2024), *The State of World Fisheries and Aquaculture 2024*, reports that aquaculture production has exceeded wild-capture fisheries for food use since 2020.
2. ¶2 FAO SOFIA 2024 confirms aquaculture's expanding share of global seafood production.
3. ¶3 SEEA CF, para 2.84-2.86
4. ¶4 SEEA CF, para 5.408
5. ¶5 SEEA CF, para 5.408
6. ¶6 SEEA CF, para 5.409, citing FAO (2008) Glossary of Aquaculture
7. ¶7 SEEA AFF, para 2.127-2.129 on distinguishing natural from cultivated processes
8. ¶8 SEEA CF, para 5.407-5.408
9. ¶9 2025 SNA, Chapter 11, para 11.206-11.208
0. ¶10 2025 SNA, para 11.214-11.216
1. ¶11 SEEA-Water provides comprehensive guidance on water abstraction accounting
2. ¶12 Kunming-Montreal Global Biodiversity Framework, Target 10: "Ensure that areas under agriculture, aquaculture, fisheries and forestry are managed sustainably, in particular through the sustainable use of biodiversity…"
3. ¶13 SEEA CF, para 5.418
4. ¶14 2025 SNA, para 11.215
5. ¶15 SEEA CF, para 5.415
6. ¶16 SEEA CF, para 5.418
7. ¶17 2025 SNA, para 11.216 (treatment of sales of livestock between establishments applies analogously to arm's-length hatchery sales)
8. ¶18 2025 SNA, paras 6.23–6.27 (vertically integrated enterprises and the valuation of deliveries between their stages) and paras 7.94, 7.96 and 7.114 (goods produced and used within one establishment are not output; intra-enterprise deliveries are recorded only where the receiving establishment decides its own supply and prices).
9. ¶19 SEEA CF, para 5.409 (FAO ownership-throughout-rearing criterion); SEEA CF, para 5.407 (natural resource extraction vs. production boundary); ISIC Rev.4, Group 032
0. ¶20 SEEA CF, para 5.416
1. ¶21 SEEA CF, para 5.417
2. ¶22 2025 SNA, Chapter 11, on the valuation of work-in-progress with non-linear growth profiles. The principle applies to aquaculture inventory valuation.
3. ¶23 2025 SNA, para 11.216
4. ¶24 ISIC Rev.4, Group 032 Aquaculture
5. ¶25 SF-MST, para 4.103, on the application of carrying capacity concepts in environmental-economic accounting
6. ¶26 SEEA AFF, para 3.90
7. ¶27 Tacon, A.G.J. and Metian, M. (2008). Global overview on the use of fish meal and fish oil in industrially compounded aquafeeds. *Aquaculture* 285: 146-158.
8. ¶28 SEEA AFF, para 3.169
9. ¶29 SEEA AFF, para 3.169; SEEA CF Chapter 3 (supply and use tables). Commercially purchased fishmeal and fish oil appear as intermediate consumption (purchased goods) in the aquaculture supply and use table. The wild fish equivalent embedded in feed is an analytical indicator (FIFO ratio) and should appear only as a supplementary satellite table or memo item to avoid double-counting the same extraction already recorded in fisheries accounts.
0. ¶30 Ytrestoyl, T., Aas, T.S. and Asgard, T. (2015). Utilisation of feed resources in production of Atlantic salmon (*Salmo salar*) in Norway. *Aquaculture* 448: 365-374.

DRAFT

1. ¶31 Holmer, M. (2010). Environmental issues of fish farming in offshore waters: perspectives, concerns and research needs. *Aquaculture Environment Interactions* 1: 57-70.
2. ¶32 SEEA CF, para 5.416
3. ¶33 FAO FishStatJ (FAO global fisheries and aquaculture production database). Average post-larval shrimp weight at nursery stocking size (PL20 or equivalent) is typically 0.1–0.5 g per individual; the assumed 0.3 g in this example should be replaced by species- and farm-specific stocking weight documentation in real compilations.
4. ¶34 Jackson, A. (2009). Fish in – fish out ratios explained. *Aquaculture Europe* 34(3): 5-10. IFFO computes FIFO as (fishmeal inclusion rate / fishmeal yield) x FCR, with a standard fishmeal yield of 22.5 per cent of raw fish.
5. ¶35 HELCOM PLC-Water Guidelines (2022) specify aquaculture nutrient thresholds for the Baltic Sea (phosphorus: 8 g/kg fish produced; nitrogen: 70 g/kg fish produced). FAO Technical Guidelines for Responsible Fisheries No. 5 (Aquaculture Development) provide species-specific reference ranges applicable more broadly.
6. ¶36 UN et al. (2021). *System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA EA)*, Chapter 6 (Ecosystem Service Accounts), Section 6.1 on provisioning services.
7. ¶37 FAO. *FishStatJ – software for fishery and aquaculture statistical time series* (aquaculture production database). FAO Fisheries and Aquaculture Division, Rome.
8. ¶38 FAO (1995). *Code of Conduct for Responsible Fisheries*, Article 7 (Fisheries Management) on the economic, social and environmental sustainability of fisheries.
9. ¶39 SEEA EA, Section 6.3 on monetary valuation of ecosystem services, including the resource rent method for provisioning services.
0. ¶40 FAO. *FishStat – global capture production database*. FAO Fisheries and Aquaculture Division, Rome.
1. ¶41 SEEA EA, Section 6.3 on stumpage-value resource rent as a directly observed exchange-price method for wood provisioning.
2. ¶42 SEEA EA, Section 6.2 on the structure of ecosystem service supply and use tables, permitting joint recording of cultivated and natural provisioning flows.

DRAFT

Offshore Energy Accounts

Compiles accounts for offshore energy resources within the ocean accounting framework.

Version 0.6.3 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

OUTCOME

After completing this Circular, readers will be able to compile accounts for offshore energy resources within the ocean accounting framework, covering both non-renewable mineral and energy resources (offshore oil and gas, seabed minerals) and the newly recognised renewable energy resources (offshore wind, tidal, and wave energy) following the 2025 SNA adoption of renewable energy resources as a distinct asset category (AN322).

Offshore energy accounts serve several decision use cases for governments managing marine resources and energy transitions. They support energy transition planning by tracking offshore fossil fuel extraction alongside renewable marine energy generation, so that policymakers can quantify progress toward decarbonisation targets and assess the changing composition of ocean-based energy portfolios. They record the depletion of non-renewable seabed resources, recognising extraction of offshore oil, gas, and minerals as consumption of natural capital rather than income, which supports depletion-adjusted national income measures. They quantify the offshore wind, tidal, and wave energy resources available for development, informing spatial planning decisions and infrastructure investment priorities. These functions connect to TG-1.1 OA and National Budget Processes and TG-2.5 Structure and Function of the Ocean Economy, where offshore energy data inform fiscal planning and economic performance monitoring.

The guidance draws on the general asset accounting methodology in TG-3.1 Asset Accounts and the economic activity classifications in TG-3.3 Economic Activity Relevant to the Ocean, and connects to greenhouse gas accounting in TG-3.4 Flows from Economy to Environment.

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 4
3.1 Asset Classification 5
3.2 Compilation Procedure 8
3.3 Offshore Wind 12
3.4 Tidal and Wave Energy 14
3.5 Offshore Oil and Gas 15
3.6 Decommissioning Considerations 17
3.7 Worked Example: Coastal State Offshore Energy Accounts 18
Implementation Considerations 23
4. Acknowledgements 23
5. References 23

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Offshore Energy Accounts (2026) (GOAP Technical Guidance on Ocean Accounting, TG-3.10, v0.6.3). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-3/3-10-offshore-energy/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

1. Outcome

¶1 After completing this Circular, readers will be able to compile accounts for offshore energy resources within the ocean accounting framework, covering both non-renewable mineral and energy resources (offshore oil and gas, seabed minerals) and the newly recognised renewable energy resources (offshore wind, tidal, and wave energy) following the 2025 SNA adoption of renewable energy resources as a distinct asset category (AN322)[1].

¶2 Offshore energy accounts serve several decision use cases for governments managing marine resources and energy transitions. They support energy transition planning by tracking offshore fossil fuel extraction alongside renewable marine energy generation, so that policymakers can quantify progress toward decarbonisation targets and assess the changing composition of ocean-based energy portfolios. They record the depletion of non-renewable seabed resources, recognising extraction of offshore oil, gas, and minerals as consumption of natural capital rather than income, which supports depletion-adjusted national income measures. They quantify the offshore wind, tidal, and wave energy resources available for development, informing spatial planning decisions and infrastructure investment priorities. These functions connect to **TG-1.1 OA and National Budget Processes** and **TG-2.5 Structure and Function of the Ocean Economy**, where offshore energy data inform fiscal planning and economic performance monitoring.

¶3 The guidance draws on the general asset accounting methodology in **TG-3.1 Asset Accounts** and the economic activity classifications in **TG-3.3 Economic Activity Relevant to the Ocean**, and connects to greenhouse gas accounting in **TG-3.4 Flows from Economy to Environment**.

2. Requirements

¶1 **Essential prerequisites:**

- ¶2 **TG-0.1 General Introduction to Ocean Accounts**: conceptual framework and scope of Ocean Accounts
- ¶3 **TG-3.1 Asset Accounts**: general asset accounting methodology including standard account structure and valuation

¶4 **Helpful background:**

- ¶5 **TG-0.2 Overview of Relevant Statistical Standards**: statistical foundations in SNA 2025, SEEA CF, and SEEA EA
- ¶6 **TG-3.3 Economic Activity Relevant to the Ocean**: industry classifications for offshore energy sectors
- ¶7 **TG-3.4 Flows from Economy to Environment**: greenhouse gas accounting related to energy production
- ¶8 **TG-2.4 Environmental (including Ecosystem) Goods and Services** Section 3.10: valuation method preference order; **TG-3.1 Asset Accounts** Section 3.3: net present value and resource rent estimation
- ¶9 **TG-6.9 Offshore Energy Thematic Methods**: the sector-operational layer built on this Circular's account structures

> ¶10 ⓘ **Scope**
> ¶11 TG-3.10 sits within Section 3 (Accounts Compilation). It owns the asset account for offshore energy resources: the SNA and SEEA CF classification of mineral, energy and renewable resources, the commercial-viability classes, the resource-rent and NPV valuation, the allocation between government and extractor, and the account rows in physical and monetary terms. The sector-operational layer — energy-type-specific measurement, spatial footprint and exclusion zones, underwater noise and electromagnetic fields, rigs-to-reefs, stranded-asset and transition accounting — is **TG-6.9 Offshore Energy Thematic Methods**, in the same relationship that TG-3.9 has to TG-6.8.

DRAFT

¶12 **Framework Position**

¶13 This Circular addresses offshore energy accounting, covering both non-renewable extraction (oil, gas, minerals) and renewable energy resources (wind, tidal, wave). Offshore energy accounts record the transformation of environmental stocks into economic flows, together with the environmental residuals generated by extraction. In the Ocean Accounts Framework (TG-0.1 Figure 0.1.2):

Edge	Direction	Description
E1	FG1 → SG3	Emissions and pollution from offshore energy production to the marine environment
E3	FG1 ↔ SG1	Energy asset transactions and production as monetary flows between economic sectors and SNA assets
E9	SG3 → FG1	Natural resource extraction as flow from environmental stocks to the economy

3. Guidance Material

¶1 The ocean domain contains energy resources central to national energy portfolios and sustainable development strategies. Offshore energy encompasses both extractive activities targeting non-renewable resources beneath the seabed (oil, natural gas, minerals) and the capture of renewable energy from marine environments (wind, tidal, wave). These activities have distinct accounting treatments, whilst sharing common challenges related to spatial delineation, valuation in the absence of market transactions, and management of environmental impacts including decommissioning obligations.

¶2 The 2025 SNA advances energy accounting by formally recognising renewable energy resources (AN322) as a distinct asset category within natural resources [2]. This recognition reflects the growing economic importance of renewable energy and provides a statistical framework for tracking these assets alongside traditional mineral and energy resources. For ocean accounting, the new asset category matters given the rapid expansion of offshore wind and emerging interest in tidal and wave energy technologies. Compilers should note that the SEEA Energy (2019), which predates the 2025 SNA, does not include renewable energy as physical assets (para. 5.8) [3]. The 2025 SNA's recognition of AN322 effectively supersedes this position for national accounts purposes, though compilers working with SEEA-based physical energy accounts should document how they reconcile the two frameworks. A future revision of SEEA Energy is expected to align with the 2025 SNA treatment.

DRAFT

¶3 This section is organised to provide both conceptual guidance and practical compilation procedures. Section 3.1 establishes the asset classification framework. Section 3.2 provides a step-by-step compilation procedure for offshore energy accounts. Sections 3.3-3.5 address specific energy types (offshore wind, tidal and wave, oil and gas). Section 3.6 covers decommissioning considerations. Section 3.7 presents a worked example with synthetic data demonstrating the full compilation workflow. Cross-references to related circulars are provided throughout.

¶4 *Table 1: Offshore energy asset-flow linkages*

Energy Type	Asset Account	Flow Account	Depletion Treatment
Oil & gas	Non-renewable mineral and energy resources (AN.321)	Extraction flows	Depletion = extraction
Wind	Renewable energy resources (AN.3221)	Energy capture flows	No physical depletion
Tidal	Water energy resources (AN.3223)	Energy capture flows	No physical depletion

Energy Type	Asset Account	Flow Account	Depletion Treatment
Wave	Water energy resources (AN.3223)	Energy capture flows	No physical depletion

¶5 *Note: Produced assets (platforms, turbines) are separate from the energy resources and are recorded in the produced asset accounts (AN.11).*

3.1 Asset Classification

¶1 Classifying an offshore energy asset turns on two sequential questions: whether it was produced or constructed and, if not, whether the underlying resource depletes with use. These questions route each asset into a produced asset account (AN11), a non-renewable natural resource account (AN321), or the renewable energy potential account (AN322), the values of which must not be summed because they are recorded in incompatible units (Figure 3.10.1).

DRAFT

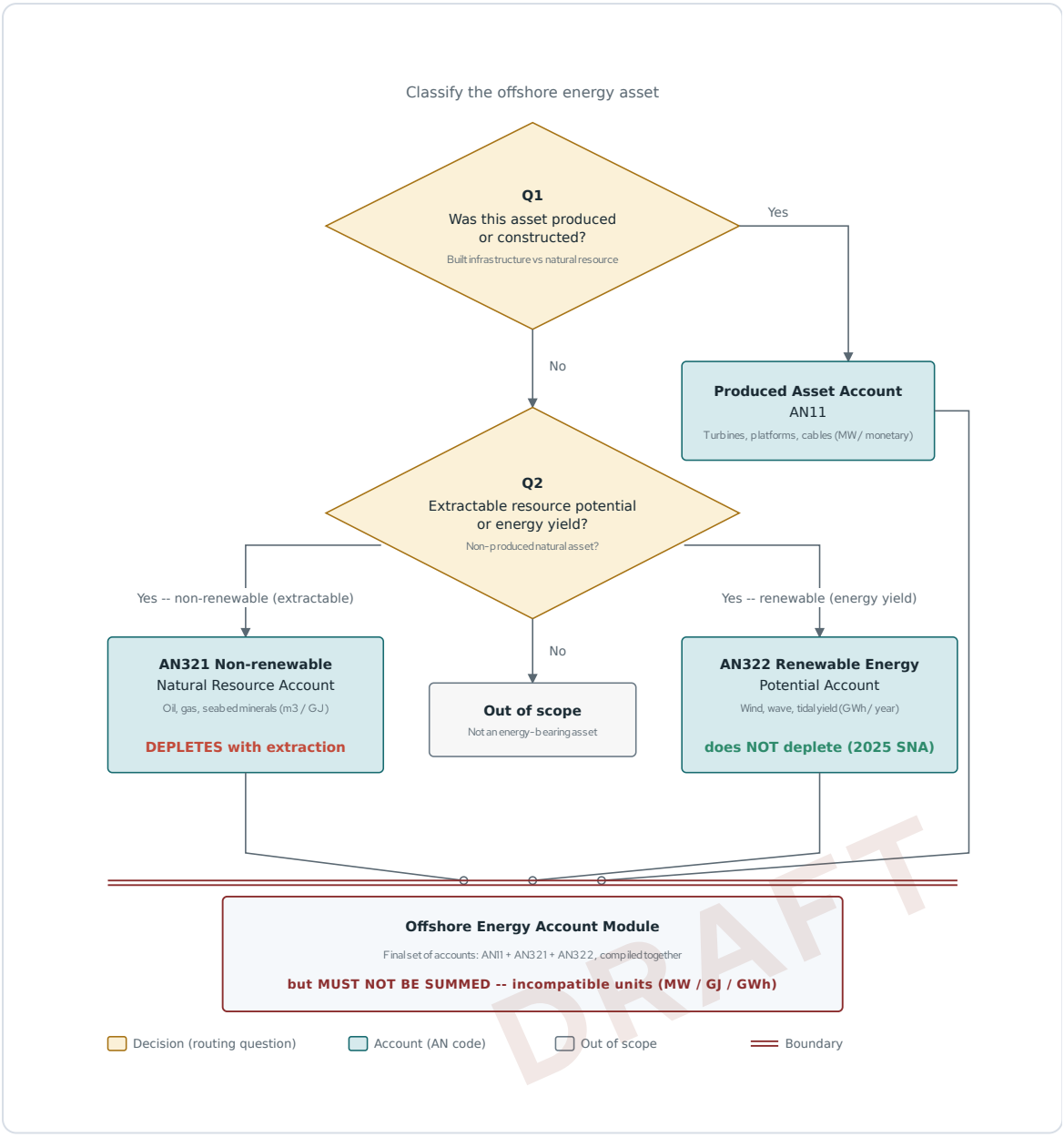


Figure 3.10.1 Two sequential questions route offshore energy assets into produced (AN11) or non-produced natural-resource accounts (AN321 or AN322). Circle docks signal incompatible units -- component values must not be summed into one total.

Source: TG-3.10 draft, §3.1 asset classification logic; SNA 2025 §13.81-13.95 (produced vs non-produced assets); SNA 2025 §13.122-13.139 (AN322 renewable energy potential, 2025 innovation); SEEA CF §5.41-5.62 (mineral and energy resources).

Adapted from: SNA 2025 asset-classification hierarchy (AN11 / AN321 / AN322), restructured as a routing decision tree with a GOAP must-not-be-summed account-boundary annotation per the Figure Style Guide §5.3.

3.1.1 The 2025 SNA classification of mineral and energy resources

¶1 The 2025 SNA establishes a classification of natural resources that provides the foundation for offshore energy accounting [4]. Under this classification, mineral and energy resources (AN32) comprise two primary categories:

1. ¶2
   Non-renewable mineral and energy resources (AN321) – consisting of known deposits of oil, natural gas, coal, peat, non-metallic minerals, and metallic minerals that are economically exploitable given current technology and relative prices [5]
2. ¶3

Renewable energy resources (AN322) — comprising the cumulative quantities of kinetic, radiative, and thermal energy recoverable from moving water (hydro and ocean energy), moving air (wind energy), hot underground and surface rock and water (geothermal resources), and incident solar radiation (solar resources)[6]

¶4 For renewable energy resources, the 2025 SNA recommends the following breakdown[7]:

- ¶5 AN3221: Wind energy resources
- ¶6 AN3222: Solar energy resources
- ¶7 AN3223: Water energy resources (including ocean energy)
- ¶8 AN3224: Geothermal energy resources
- ¶9 AN3229: Other renewable energy resources

¶10 This classification enables separate tracking of offshore wind (AN3221) and marine-based water energy including tidal and wave (AN3223) within a coherent statistical framework.

3.1.2 Relationship between renewable energy resources and land

¶1 A central conceptual issue for offshore energy accounting concerns the relationship between renewable energy resources and land (or seabed). The 2025 SNA notes that "although these resources as such are generally not scarce, the exploitation of these resources may be restricted to certain economic agents, for example by needing permissions to put wind turbines on land, or having ownership of particular pieces of land which are highly favourable for exploiting renewable resources"[8].

¶2 The SEEA CF addresses this issue directly for offshore renewable energy: "It is recognized that some investments in the capture of energy from renewable sources take place offshore (e.g., wind farms in the sea). By convention, the value of income streams from these sources are attributed to the value of land"[9]. Under this convention the value of offshore renewable energy resources is conceptually linked to the value of the seabed or marine areas over which exploitation rights are exercised.

¶3 For practical accounting purposes, this guidance implies that:

1. ¶4 The physical potential for renewable energy generation should be recorded in physical asset accounts
2. ¶5 The monetary value of these resources, where quantified, may be attributed to land/seabed values
3. ¶6 Permits and licences for offshore energy exploitation may themselves constitute separate assets (AN212 — Permits to undertake specific activities)[10]

¶7 The treatment of offshore marine areas as "land" for accounting purposes is a convention adopted in the SEEA CF to enable valuation of renewable energy resources in locations where traditional land ownership does not apply. For ocean accounting, this convention should be understood within the broader spatial framework for marine areas established in **TG-0.2 Overview of Relevant Statistical Standards**. In practice, the economic value attributed to seabed areas reflects the present value of expected income streams from energy exploitation, including the effect of any regulatory restrictions on access. Compilers should record the spatial location of these assets using the Basic Spatial Unit (BSU) approach and document the convention applied.

3.1.3 Distinguishing produced assets from natural resources

¶1 Offshore energy accounting requires careful distinction between natural resource assets and the produced assets (fixed capital) used to exploit them. For offshore energy:

- ¶2 **Natural resource assets** include the oil and gas deposits themselves, seabed mineral resources, and the renewable energy potential of offshore locations

DRAFT

- ¶3 **Produced assets** include drilling platforms, pipelines, wind turbines, tidal turbines, substations, and associated infrastructure

¶4 The 2025 SNA emphasises that "the costs of ownership transfer, which are part of fixed capital formation, must be shown separately in the capital account and not as part of the value of the transaction in the non-produced asset"[11]. This separation ensures that investments in extraction/generation infrastructure are properly distinguished from the underlying natural resources.

¶5 For aquatic resources, a parallel distinction applies between cultivated and natural resources[12]. However, for mineral and energy resources, all such resources are classified as non-produced natural resources regardless of the intensity of extraction activity.

3.2 Compilation Procedure

¶1 This section provides a step-by-step procedure for compiling offshore energy accounts, applicable to both renewable and non-renewable energy resources. The procedure follows the general asset account compilation methodology from **TG-3.1 Asset Accounts**, adapted for energy-specific considerations.

Step 1: Define scope and spatial boundaries

¶1 Determine the spatial coverage of offshore energy accounts:

- ¶2 **Marine area definition** — identify the portions of the Exclusive Economic Zone (EEZ), territorial sea, or extended continental shelf where energy resources are located or exploited
- ¶3 **BSU alignment** — ensure offshore energy data can be spatially linked to the Basic Spatial Unit framework used for ocean accounts
- ¶4 **Coordination with terrestrial accounts** — establish boundaries between offshore and onshore energy accounts to avoid double-counting (particularly relevant for nearshore installations)

¶5 Document the spatial conventions applied and any deviations from standard maritime boundaries.

DRAFT

Step 2: Identify data sources

¶1 Compile relevant data sources for physical stocks and flows:

¶2 **For offshore oil and gas:**

- ¶3 Geological surveys and resource assessments from national petroleum agencies
- ¶4 Production data from extractive industries (volumes, locations, field-level details)
- ¶5 Reserve estimates classified according to UNFC-2009 or equivalent frameworks
- ¶6 Seismic survey data and well completion reports

¶7 **For offshore wind:**

- ¶8 Wind resource assessments (wind speed, frequency distributions by location)
- ¶9 Installed capacity registers (turbine count, nameplate capacity, commissioning dates)
- ¶10 Generation data from transmission system operators
- ¶11 Lease area boundaries and development consents

¶12 **For tidal and wave energy:**

- ¶13 Oceanographic data (tidal range, current velocities, wave climate)
- ¶14 Pilot project registrations and demonstration installations
- ¶15 Feasibility studies identifying technically exploitable sites

¶16 **For monetary valuation:**

- ¶17 Energy prices (oil benchmarks, gas prices, electricity wholesale prices)
- ¶18 Operating cost data from industry or regulatory sources
- ¶19 Discount rates from national treasury or central bank guidance
- ¶20 Decommissioning cost estimates and bonding requirements

Step 3: Classify resources by asset category

¶1 Apply the 2025 SNA classification framework:

- ¶2 **Non-renewable resources (AN321)** — offshore oil, natural gas, seabed minerals
- ¶3 **Renewable resources (AN322)** — offshore wind (AN3221), tidal and wave (AN3223)

¶4 For non-renewable resources, further classify by resource class using UNFC-2009:

- ¶5 Class A: Commercially recoverable resources
- ¶6 Class B: Potentially commercially recoverable resources
- ¶7 Class C: Non-commercial and other known deposits

¶8 For renewable resources, classify by technology maturity:

- ¶9 Operational installations (existing generating capacity)
- ¶10 Consented projects (approved for development but not yet built)
- ¶11 Resource potential (technical potential not yet subject to development consent)

Step 4: Compile physical opening stocks

¶1 Record the physical quantity of each asset category at the beginning of the accounting period:

- ¶2 **Oil and gas** — volumes in place (barrels of oil equivalent, cubic metres) by field and resource class
- ¶3 **Offshore wind** — installed capacity (MW) by location, technology type (fixed-bottom, floating), and water depth
- ¶4 **Tidal and wave** — installed capacity (MW) where operational, and theoretical potential (TWh/year) for undeveloped resources

¶5 Ensure consistency with closing stocks from the previous accounting period. Where this is the first compilation, document the method used to establish initial stocks and any assumptions required.

DRAFT

Step 5: Record additions to stock

¶1 Identify and quantify all increases in resource stocks during the accounting period:

¶2 **For non-renewable resources:**

- ¶3 **Discoveries** — new fields identified through exploration
- ¶4 **Upward reappraisals** — revisions increasing estimated reserves based on improved geological knowledge
- ¶5 **Reclassifications** — transfers from Class B to Class A as economic conditions or project status changes

¶6 **For renewable resources:**

- ¶7 **New installations** — capacity additions from newly commissioned projects
- ¶8 **Resource assessments** — improved estimates of technical potential based on enhanced oceanographic data
- ¶9 **Technology advances** — increases in exploitable potential due to technological improvements (e.g., deeper water turbine foundations)

Step 6: Record reductions in stock

¶1 Identify and quantify all decreases in resource stocks during the accounting period:

¶2 **For non-renewable resources:**

- ¶3 **Extraction** – volumes of oil and gas produced and removed from deposits
- ¶4 **Downward reappraisals** – revisions reducing estimated reserves
- ¶5 **Reclassifications** – transfers from Class A to Class B or C due to changing economic conditions
- ¶6 **Catastrophic losses** – rare for subsurface deposits but may include uncontrolled well events

¶7 **For renewable resources:**

- ¶8 **Decommissioning** – removal of installed capacity at end of operational life
- ¶9 **Catastrophic losses** – destruction of turbines due to extreme weather or marine accidents
- ¶10 **Downward reassessments** – reductions in estimated technical potential due to spatial conflicts (e.g., designation of marine protected areas precluding energy development)

¶11 Note that for renewable resources, there is no equivalent to "extraction" as a stock reduction, since the energy source itself is not depleted by use[13].

Step 7: Calculate physical closing stocks

¶1 Apply the asset account identity:

¶2 **Closing stock = Opening stock + Total additions - Total reductions**

¶3 Verify that the calculated closing stock is consistent with independent assessments where available. Investigate and reconcile any material discrepancies.

Step 8: Estimate monetary values

¶1 Apply valuation methods appropriate to each asset type, following **TG-2.4 Environmental (including Ecosystem) Goods and Services** Section 3.10 and **TG-3.1 Asset Accounts** Section 3.3:

¶2 **For commercially recoverable oil and gas (Class A):**

¶3 Use the net present value (NPV) approach based on expected resource rents:

¶4 NPV = Σ (Resource rent in year t) / (1 + discount rate)^t

¶5 Where resource rent = Revenue - Operating costs - User costs of produced capital - Return to produced capital

¶6 Key parameters:

- ¶7 Expected extraction profile over remaining field life
- ¶8 Oil and gas price assumptions (consider long-term price paths, not spot prices)
- ¶9 Operating costs per unit extracted
- ¶10 Capital costs and depreciation of platforms, pipelines, processing facilities
- ¶11 Discount rate (typically national treasury bond rate plus risk premium)

¶12 **For offshore wind:**

¶13 Estimate NPV based on expected electricity generation and power prices:

¶14 NPV = Σ [(Generation × Electricity price) - Operating costs - User costs of turbines] / (1 + discount rate)^t

¶15 Key parameters:

- ¶16 Expected generation profile (capacity factor typically 35-50% for offshore wind)
- ¶17 Electricity price path (may reflect long-term power purchase agreements)
- ¶18 Operating and maintenance costs
- ¶19 Asset life (typically 25-30 years for offshore wind)

DRAFT

¶20 Where market transactions in offshore wind lease rights exist, these may provide direct indicators of resource value.

¶21 **For tidal and wave:**

¶22 Given limited commercial deployment, monetary valuation may not be feasible. Record physical potential and flag for future valuation as technologies mature.

Step 9: Allocate assets between government and extractors

¶1 For non-renewable resources subject to government ownership and licensing arrangements, allocate asset values between:

- ¶2 **Government** – reflecting ownership of in situ resources and receipt of resource rents through royalties, production shares, or resource taxes
- ¶3 **Extractors** – reflecting their share of resource rents after government take

¶4 Follow the methodology in SEEA CF paragraphs 5.216-5.224 and document the fiscal regime applied (concession, production sharing, service contract, or hybrid)[14].

¶5 For renewable resources on the seabed, allocation follows the same principles where lease payments or revenue shares apply.

Step 10: Compile monetary asset accounts

¶1 Construct monetary asset accounts parallel to physical accounts, recording:

- ¶2 Opening stock (monetary value)
- ¶3 Revaluations (due to price changes)
- ¶4 Other changes in volume (discoveries, extractions, reappraisals, reclassifications valued at current prices)
- ¶5 Closing stock (monetary value)

¶6 Ensure that monetary depletion (extraction valued at resource price in situ) is recorded and reported as a reduction in net domestic product following 2025 SNA treatment[15].

DRAFT

Step 11: Integrate with economic and emissions accounts

¶1 Link offshore energy accounts to related accounts:

¶2 **Upward linkages:**

- ¶3 Feed offshore energy production data into ocean economy GDP calculations (**TG-2.5 Structure and Function of the Ocean Economy**)
- ¶4 Provide asset values for natural capital balance sheets in ocean budgets (**TG-1.1 OA and National Budget Processes**)
- ¶5 Support energy transition indicators (**TG-2.1 Aggregate Biophysical Indicators of Environmental State**)

¶6 **Downward linkages:**

- ¶7 Source underlying data from administrative registers (**TG-4.3 Administrative Data Sources**)
- ¶8 Quality-assure estimates using the national statistical agency's own validation rules, documented as set out in **TG-0.7 Quality Assurance Principles**

¶9 **Lateral linkages:**

- ¶10 Allocate greenhouse gas emissions from oil and gas extraction to marine spatial units (**TG-3.4 Flows from Economy to Environment**)
- ¶11 Reconcile with broader economic activity accounts (**TG-3.3 Economic Activity Relevant to the Ocean**)

3.3 Offshore Wind

3.3.1 Scope and measurement boundary

¶1 Offshore wind energy has expanded in recent decades, with installed capacity growing in major maritime economies. For ocean accounting purposes, the measurement scope encompasses:

- ¶2 **Physical resource potential** – the theoretical and technical potential for wind energy generation at offshore locations, measured in terms of wind speed, consistency, and site characteristics
- ¶3 **Installed capacity** – the maximum power output of installed wind generation equipment (measured in megawatts, MW)
- ¶4 **Actual generation** – electricity produced from offshore wind (measured in megawatt-hours, MWh, or equivalent energy units such as terajoules, TJ)
- ¶5 **Infrastructure assets** – turbines, foundations, substations, cables, and other produced assets

¶6 The SEEA Energy framework provides that "renewable sources of energy such as wind, solar and hydropower are not considered physical assets" in the sense that "there is no physical stock of these types of renewable sources of energy that can be used up or sold"[16]. The 2025 SNA's recognition of renewable energy resources (AN322) establishes a revised basis for recording these resources as assets where economic ownership can be established. In practical terms, the asset recognised under AN322 is best understood as the right to exploit the renewable energy potential at a given location, rather than the wind resource itself. Under this interpretation the SEEA Energy position holds that the wind as a physical phenomenon is inexhaustible and cannot be "used up", whilst the 2025 SNA recognises that economic rights over favourable locations have measurable value. Compilers should record the physical resource potential (energy generation capacity) in physical accounts whilst attributing the monetary value to the combination of locational advantage and exploitation rights.

DRAFT

3.3.2 Physical accounts for offshore wind

¶1 Physical accounts for offshore wind should record:

¶2 **Stock measures (at a point in time):**

- ¶3 Installed capacity by location, technology type, and water depth category
- ¶4 Number of turbines and average capacity
- ¶5 Geographic distribution within exclusive economic zone

¶6 **Flow measures (during accounting period):**

- ¶7 Capacity additions (new installations)
- ¶8 Capacity reductions (decommissioned units)
- ¶9 Electricity generation
- ¶10 Capacity utilisation rates

¶11 Table 2 provides an example structure for a physical account of offshore wind capacity. The structure follows the general asset account format established in **TG-3.1 Asset Accounts**, adapted for renewable energy infrastructure. Compilers may disaggregate further by water depth category (shallow, transitional, deep), distance from shore, or marine planning area as appropriate for national circumstances.

¶12 *Table 2: Physical account for offshore wind capacity (MW)*

Item	Fixed-bottom	Floating	Total
Opening stock of installed capacity	5,000	200	5,200

Item	Fixed-bottom	Floating	Total
Additions during period			
- New installations	800	100	900
Reductions during period			
- Decommissioning	50	0	50
- Catastrophic losses	0	0	0
Closing stock of installed capacity	5,750	300	6,050

3.3.3 Monetary valuation of offshore wind resources

¶1 The monetary value of offshore wind resources can be estimated using the net present value (NPV) approach[17]. The resource rent attributable to offshore wind comprises the income remaining after deducting all costs including:

- ¶2 Operating and maintenance costs
- ¶3 User costs of produced assets (depreciation of turbines, foundations, cables)
- ¶4 Return to produced capital
- ¶5 Any payments to government for exploitation rights

¶6 The SEEA CF notes that "opportunities to earn resource rent based on sources like wind, solar and geothermal should be expected to be reflected in the price of land"[18]. For offshore wind, this implies that the value of seabed lease rights or development permits may provide market-based indicators of resource value.

¶7 Key considerations for NPV calculations include:

1. ¶8 **Expected generation profile** – accounting for capacity factors that vary by location and technology
2. ¶9 **Electricity price assumptions** – including long-term power purchase agreements where applicable
3. ¶10 **Operating life** – typically 25-30 years for offshore wind installations
4. ¶11 **Discount rate** – consistent with rates applied to other natural resources in national accounts

¶12 For worked examples applying the NPV approach to offshore energy resources, see Section 3.7 below and **TG-6.9 Offshore Energy Thematic Methods**.

3.3.4 Spatial considerations

¶1 Offshore wind development occurs within designated lease areas typically located within the exclusive economic zone (EEZ). The spatial framework for ocean accounts should enable linking of offshore wind data to specific marine areas using the Basic Spatial Unit (BSU) approach[19].

¶2 Spatial data requirements include:

- ¶3 Lease area boundaries and their relationship to statistical marine areas
- ¶4 Water depth and seabed characteristics
- ¶5 Proximity to grid connection points
- ¶6 Overlap or interaction with other marine uses (shipping lanes, fishing grounds, marine protected areas)

¶7 Spatial data support analysis of interactions between offshore wind and marine ecosystems, informing integrated ocean management decisions. Cross-reference to **TG-3.3 Economic Activity Relevant to the Ocean** for the classification of offshore wind as an ocean economy activity, and **TG-3.4 Flows from Economy to Environment** for recording any environmental pressures associated with wind farm construction and operation.

DRAFT

3.4 Tidal and Wave Energy

3.4.1 Classification and measurement scope

¶1 Tidal and wave energy represent emerging renewable energy technologies that capture energy from ocean water movement. Under the 2025 SNA classification, these resources fall within water energy resources (AN3223)[20].

¶2 The SEEA Central Framework and FDES define renewable energy from marine sources to include[21]:

- ¶3 **Tidal energy** – energy captured from tidal flows and tidal range (barrage systems)
- ¶4 **Wave energy** – energy captured from surface waves
- ¶5 **Ocean thermal energy conversion (OTEC)** – energy derived from temperature differences between surface and deep ocean waters
- ¶6 **Salinity gradient energy** – energy from salinity differences between freshwater and seawater

¶7 These technologies are at varying stages of commercial development, with tidal stream and tidal barrage representing the most mature approaches. Wave energy technologies remain largely at demonstration stage in most jurisdictions. Accordingly, guidance for tidal and wave energy follows the same accounting principles as offshore wind, whilst recognising that data availability will be more limited and that compilation methods may need to accommodate fast-changing technologies. As marine renewable energy technologies mature and deployment scales increase, this section may be expanded in future revisions of this Circular to provide more detailed guidance on measurement methods and accounting treatments specific to each technology type.

3.4.2 Physical accounts for tidal and wave energy

¶1 Physical accounts for tidal and wave energy should follow the same structure as offshore wind, recording:

¶2 **Stock measures:**

- ¶3 Installed capacity by technology type (tidal stream, tidal range, wave)
- ¶4 Location and characteristics of installations

¶5 **Flow measures:**

- ¶6 Energy generation during accounting period
- ¶7 Capacity additions and reductions

¶8 Given the early stage of deployment, many countries will have zero or minimal entries for tidal and wave energy capacity. Establishing the accounting framework now nonetheless allows tracking as these technologies mature.

3.4.3 Resource assessment and potential

¶1 Unlike wind resources which can be assessed through established meteorological methods, tidal and wave energy potential requires oceanographic measurement of:

- ¶2 Tidal range and current velocities at potential sites
- ¶3 Wave height, period, and direction statistics
- ¶4 Seasonal and inter-annual variability

¶5 These assessments provide the physical basis for understanding exploitable resources, analogous to resource classification for mineral deposits. The three-class framework used for mineral resources in SEEA Energy (commercially recoverable, potentially commercially recoverable, non-commercial)[22] could be adapted for emerging marine renewable resources to distinguish sites by development readiness.

DRAFT

3.5 Offshore Oil and Gas

3.5.1 Asset classification framework

¶1 Offshore oil and natural gas deposits are classified as non-renewable mineral and energy resources (AN321) within the 2025 SNA framework[23]. The SEEA Central Framework and SEEA Energy provide detailed guidance on asset accounts for these resources, based on the United Nations Framework Classification for Resources (UNFC-2009)[24].

¶2 The UNFC categorises mineral and energy resources according to three criteria:

- ¶3 **Economic and social viability (E)** – the degree of favourability of conditions for commercial viability
- ¶4 **Field project status and feasibility (F)** – the maturity of development plans
- ¶5 **Geologic knowledge (G)** – the level of certainty regarding quantities

¶6 These criteria define three classes of known deposits[25]:

- ¶7 **Class A: Commercially recoverable resources** – deposits where extraction has been confirmed economically viable (E1, F1)
- ¶8 **Class B: Potentially commercially recoverable resources** – deposits expected to become economically viable (E2 or E1, F2.1 or F2.2)
- ¶9 **Class C: Non-commercial and other known deposits** – deposits not expected to become viable in the foreseeable future (E3)

¶10 For monetary valuation and balance sheet purposes, only Class A resources are typically valued, as the timing and magnitude of income from Class B and C resources cannot be determined with confidence[26].

¶11 Compilers should note that the UNFC has been updated since 2009, with the UNFC-2019 incorporating specifications for renewable energy resources and injection projects alongside the original fossil energy and mineral resource categories. The three-class framework (A, B, C) used in the SEEA Energy remains applicable for non-renewable resources. For renewable energy resources, the UNFC-2019 bridging document provides mapping between UNFC categories and the 2025 SNA asset classification, though practical application to offshore renewables is still developing.

DRAFT

3.5.2 Physical asset accounts

¶1 Physical asset accounts for offshore oil and gas should record opening and closing stocks and all changes during the accounting period[27]. The standard categories of change include:

¶2 **Additions to stock:**

- ¶3 Discoveries – new deposits confirmed during the period
- ¶4 Upward reappraisals – revisions based on improved information
- ¶5 Reclassifications – transfers between resource classes

¶6 **Reductions in stock:**

- ¶7 Extraction – quantities removed from deposits
- ¶8 Catastrophic losses – rare for subsurface resources but may include uncontrolled well events
- ¶9 Downward reappraisals – revisions reducing estimated quantities
- ¶10 Reclassifications – transfers between resource classes

¶11 Table 3 provides an example structure. The format follows the general asset account structure established in **TG-3.1 Asset Accounts**. Compilers should disaggregate by field, marine area, or resource class as appropriate, using the BSU spatial framework to enable integration with other ocean accounts.

¶12 *Table 3: Physical asset account for offshore oil resources (Class A, million barrels)*

Item	Amount
Opening stock of commercially recoverable resources	800
Additions to stock	
- Discoveries	50
- Upward reappraisals	30
- Reclassifications from Class B	20
Total additions	100
Reductions in stock	
- Extraction	40
- Catastrophic losses	0
- Downward reappraisals	10
Total reductions	50
Closing stock of commercially recoverable resources	850

3.5.3 Monetary valuation

¶1 The monetary value of offshore oil and gas resources is estimated using the NPV approach, based on expected future resource rents [28]. Resource rent represents the surplus income after deducting:

- ¶2 Operating costs of extraction
- ¶3 User costs of produced capital (depreciation plus return)
- ¶4 Costs of mineral exploration and evaluation

¶5 Key considerations include:

¶6 **Price volatility**: Oil and gas prices fluctuate, creating volatility in resource rent estimates. The SEEA Energy recommends using smoothed price series or proxies (e.g., moving averages) to derive unit resource rents for projection [29].

¶7 **Resource life**: The resource life (stock divided by extraction rate) determines the period over which resource rents are discounted. At current extraction rates, this may range from under 10 years to several decades depending on field characteristics [30].

¶8 **Depletion**: For non-renewable resources, physical depletion equals extraction. In the Ocean Accounts Framework (TG-0.1), this corresponds to Edge E9 (SG3 → FG1), where extraction of environmental stocks feeds economic production flows. Monetary depletion is calculated by multiplying physical extraction by the resource price in situ [31]. The 2025 SNA treats depletion as a cost of production alongside depreciation, supporting depletion-adjusted measures of income [32].

3.5.4 Allocation of income and assets

¶1 Offshore oil and gas resources are typically subject to government ownership, with extraction conducted by licensees who pay various forms of rent (royalties, production sharing, resource taxes). The SEEA CF provides guidance on allocating assets and depletion between government and extractors based on their respective shares of resource rent [33].

¶2 The recommended treatment records:

- ¶3 Total depletion in the production account of the extractor
- ¶4 Rent payments from extractor to government in the allocation of primary income account
- ¶5 A balancing entry "depletion borne by government" reflecting the government's share of depletion

¶6 This ensures that depletion-adjusted measures correctly attribute the cost of resource use to both extractors and resource owners. The allocation of assets and depletion between government

DRAFT

and extractors varies by jurisdiction depending on the fiscal regime applied to offshore resources (royalties, production sharing agreements, resource rent taxes, or hybrid systems). For detailed treatment of asset allocation methodology, see **TG-3.1 Asset Accounts**. Compilers should document the national fiscal arrangements and allocation methodology applied in their compilations.

3.5.5 Greenhouse gas implications

¶1 Offshore oil and gas extraction generates greenhouse gas emissions through:

- ¶2 Combustion of fuels for extraction operations
- ¶3 Flaring and venting of associated gas
- ¶4 Fugitive emissions from equipment and processes
- ¶5 Downstream emissions from the use of extracted products

¶6 These emissions should be recorded in emissions accounts following the guidance in **TG-3.4 Flows from Economy to Environment**. In the Ocean Accounts Framework (TG-0.1), these residual flows correspond to Edge E1 (FG1→SG3), recording pollution and emissions from economic production to the marine and atmospheric environment. The spatial attribution of emissions to marine areas enables analysis of ocean-based contributions to national greenhouse gas inventories.

¶7 As the energy transition proceeds, offshore oil and gas accounts need to be read alongside renewable energy accounts. Tracking both within a consistent framework supports analysis of energy system transformation and its implications for ocean economies.

3.6 Decommissioning Considerations

3.6.1 Framework for decommissioning costs

¶1 Offshore energy installations require decommissioning at end of operating life, with potential environmental remediation obligations. The SEEA CF provides detailed guidance on accounting for these costs, distinguishing between [34]:

- ¶2 **Terminal costs** – costs anticipated during production that can be provided for over the asset's life
- ¶3 **Remedial costs** – costs incurred after operations cease, often by parties other than the original operator

¶4 Terminal costs should be anticipated and written off over the operating life of the associated fixed asset through consumption of fixed capital (depreciation) [35]. This treatment ensures that net income measures properly reflect the full costs of resource extraction, including future restoration obligations.

¶5 The 2025 SNA defines terminal costs as "Costs incurred on the disposal of an asset or at the end of its service life. These cover, for example, de-installation and decommissioning costs (in case of oil rigs or nuclear power stations) or rehabilitation costs of land sites" [36].

3.6.2 Application to offshore oil and gas

¶1 For offshore oil and gas platforms, decommissioning typically involves:

- ¶2 Plugging and abandonment of wells
- ¶3 Removal of platforms and surface facilities
- ¶4 Removal or stabilisation of pipelines
- ¶5 Environmental remediation of the site

¶6 The SEEA CF notes that for oil rigs, the original owner may no longer be an active business when decommissioning is required, creating challenges for cost recovery [37]. The accounting treatment provides for several scenarios:

DRAFT

1. ¶7 **Terminal costs exceed accumulated provision** — the shortfall is written off as depreciation when incurred
2. ¶8 **No provision made** — terminal costs are treated as gross fixed capital formation and immediately depreciated
3. ¶9 **Terminal costs not incurred by operator** — subsequent costs by other parties are treated as remedial costs

¶10 In practice, offshore energy decommissioning often involves complex ownership structures, including joint ventures and transfers of ownership during the asset's life. While the accounting principles above apply regardless of ownership structure, compilers should document the ownership arrangements at the time of decommissioning and allocate costs to the responsible economic units accordingly. Where decommissioning obligations transfer with asset ownership, the present value of future decommissioning costs effectively reduces the transfer price of the asset.

3.6.3 Decommissioning of renewable energy infrastructure

¶1 Offshore wind and other renewable energy infrastructure also requires end-of-life management, though the obligations may differ from oil and gas:

- ¶2 Removal of turbines, foundations, and cables
- ¶3 Restoration of seabed conditions where required
- ¶4 Potential for repowering (replacement with new equipment) rather than full decommissioning

¶5 The same framework applies: anticipated terminal costs should be provided for through depreciation of the associated fixed assets over their operating lives. This ensures consistency between conventional and renewable offshore energy accounting.

3.6.4 Environmental and ecosystem considerations

¶1 Decommissioning decisions have implications for marine ecosystems that may colonise offshore structures during their operating lives. Platform structures and turbine foundations can function as artificial reefs, supporting marine biodiversity[38]. Accounting for these ecosystem effects requires integration with ecosystem accounting approaches covered in **TG-3.1 Asset Accounts** and the broader ecosystem extent and condition accounts described in SEEA Ecosystem Accounting.

¶2 "Rigs-to-reefs" programmes that convert decommissioned platforms to permanent artificial reefs represent a transfer of assets rather than full removal. The accounting treatment should reflect:

- ¶3 Reduction in produced asset value (platform as industrial asset)
- ¶4 Potential creation or enhancement of ecosystem asset value (artificial reef)
- ¶5 Any ongoing monitoring or management obligations

¶6 Whether a rigs-to-reefs structure qualifies as an ecosystem asset depends on whether it meets the SEEA EA criteria for ecosystem extent and condition: the structure must support a self-sustaining biological community over a defined spatial area and provide measurable ecosystem services[39]. Where these criteria are met, the transition from produced asset to ecosystem asset represents a reclassification that should be recorded in the other changes in volume of assets account. Compilers should coordinate with ecosystem accounting teams (see SEEA EA Chapter 4 on ecosystem extent accounts) and document the criteria applied.

3.7 Worked Example: Coastal State Offshore Energy Accounts

¶1 This section presents a worked example demonstrating the compilation of offshore energy accounts for a hypothetical Coastal State. The example uses synthetic data to illustrate the full workflow from data collection through to integrated energy transition indicators. The example covers a five-year period (2020-2024) during which Coastal State transitions from offshore oil and gas dominance to renewable energy deployment.

DRAFT

3.7.1 Context and policy questions

¶1 **Coastal State context:**

- ¶2 EEZ area: 150,000 km²
- ¶3 Mature offshore oil and gas sector with declining reserves
- ¶4 Offshore wind expansion target: 10 GW by 2030
- ¶5 Emerging tidal energy pilot projects in high-current straits
- ¶6 Policy goal: Net zero carbon by 2050 with offshore renewables providing 40% of electricity

¶7 **Key policy questions informing account design:**

1. ¶8 What is the rate of depletion of offshore oil and gas reserves, and when will reserves be exhausted at current extraction rates?
2. ¶9 What is the change in natural capital value as the offshore energy mix shifts from non-renewable to renewable resources?
3. ¶10 What is the contribution of offshore energy to national GDP when adjusted for resource depletion?
4. ¶11 How much has offshore renewable energy capacity expanded, and is the pace sufficient to meet 2030 targets?

3.7.2 Physical accounts: Offshore oil (Class A)

¶1 *Table 4: Physical asset account for offshore oil (Class A), 2024 (million barrels)*

Item	Amount
Opening stock (1 Jan 2024)	920
Additions to stock	
- Discoveries	15
- Upward reappraisals	25
- Reclassifications from Class B	10
Total additions	50
Reductions in stock	
- Extraction	65
- Downward reappraisals	5
- Reclassifications to Class C	0
Total reductions	70
Closing stock (31 Dec 2024)	900
Memo: Resource life at current extraction rate	**13.8 years**

DRAFT

¶2 **Interpretation:** Offshore oil reserves declined by 20 million barrels net during 2024. At the current extraction rate of 65 million barrels per year, remaining reserves will be exhausted in approximately 14 years (900 ÷ 65 = 13.8). This signals the need for economic diversification as oil reserves decline.

3.7.3 Physical accounts: Offshore wind

¶1 *Table 5: Physical asset account for offshore wind capacity, 2024 (MW)*

Item	Fixed-bottom	Floating	Total
Opening stock (1 Jan 2024)	4,200	150	4,350
Additions to stock			
- New installations	950	250	1,200

Item	Fixed-bottom	Floating	Total
- Upward reassessments	0	0	0
Total additions	950	250	1,200
Reductions in stock			
- Decommissioning	80	0	80
- Catastrophic losses	0	0	0
Total reductions	80	0	80
Closing stock (31 Dec 2024)	5,070	400	5,470
Memo: Annual generation (GWh)	**18,250**	**1,440**	**19,690**
Capacity factor	**41%**	**41%**	**41%**

¶2 **Interpretation:** Offshore wind capacity increased by 1,120 MW net during 2024, representing 25% growth. Total installed capacity of 5,470 MW is 55% of the 2030 target (10,000 MW), requiring continued expansion at approximately 750 MW per year to reach the target. Capacity factor of 41% is consistent with international benchmarks for offshore wind.

3.7.4 Monetary valuation: Offshore oil

¶1 *Table 6: Monetary asset account for offshore oil (Class A), 2024 (million USD)*

Item	Amount
Opening stock (1 Jan 2024)	27,600
Additions to stock	
- Discoveries	450
- Upward reappraisals	750
- Reclassifications from Class B	300
Total additions	1,500
Reductions in stock	
- Extraction (depletion)	1,950
- Downward reappraisals	150
Total reductions	2,100
Revaluations	200
Closing stock (31 Dec 2024)	27,200

DRAFT

¶2 **Valuation assumptions:**

- ¶3 Oil price in situ: USD 30 per barrel (world oil price USD 75/barrel minus extraction costs USD 30/barrel, user costs USD 15/barrel)
- ¶4 Discount rate: 7% real
- ¶5 Average resource life: 14 years
- ¶6 Resource rent calculation follows SEEA CF para. 5.194-5.213

¶7 **Interpretation:** The monetary value of offshore oil reserves declined by USD 400 million during 2024. Depletion of USD 1,950 million represents consumption of natural capital that should be deducted from GDP to calculate depletion-adjusted net domestic product (NDP). Price revaluations added USD 200 million due to strengthening of long-term oil price expectations.

3.7.5 Monetary valuation: Offshore wind

¶1 *Table 7: Monetary asset account for offshore wind resources, 2024 (million USD)*

Item	Amount
Opening stock (1 Jan 2024)	8,200
Additions to stock	
- New installations	2,640
- Reassessments	0
Total additions	2,640
Reductions in stock	
- Decommissioning	80
Total reductions	80
Revaluations	420
Closing stock (31 Dec 2024)	11,180

¶2 **Valuation assumptions:**

- ¶3 Average resource rent per MW of capacity: USD 2.2 million (based on NPV of expected generation over 25-year asset life)
- ¶4 Electricity price: USD 65/MWh (long-term power purchase agreement price)
- ¶5 Operating costs: USD 25/MWh
- ¶6 Capacity factor: 41%
- ¶7 Discount rate: 7% real
- ¶8 Resource rent calculation reflects post-2025 SNA recognition of renewable energy resources as assets (AN3221)

¶9 **Interpretation:** The value of offshore wind resources increased by USD 2,980 million during 2024, driven by capacity additions (1,200 MW × USD 2.2 million/MW = USD 2,640 million) and revaluations due to improved long-term electricity price outlook (USD 420 million). Unlike oil reserves, there is no depletion of renewable energy resources since the wind itself is not consumed.

DRAFT

3.7.6 Integrated energy transition indicators

¶1 *Table 8: Coastal State offshore energy transition dashboard, 2020-2024*

Indicator	2020	2021	2022	2023	2024
Physical stocks					
Offshore oil reserves (million barrels)	1,050	1,020	980	920	900
Offshore wind capacity (MW)	2,100	2,800	3,600	4,350	5,470
Monetary values					
Oil asset value (million USD)	31,500	30,600	29,400	27,600	27,200
Wind asset value (million USD)	3,800	5,040	6,480	8,200	11,180
Total offshore energy asset value	**35,300**	**35,640**	**35,880**	**35,800**	**38,380**
Energy production					
Oil production (million barrels)	60	60	62	64	65
Wind generation (GWh)	7,560	10,080	12,960	15,660	19,690
Economic indicators					
Oil depletion (million USD)	1,800	1,800	1,860	1,920	1,950
Offshore energy contribution to GDP (million USD)	4,200	4,350	4,530	4,740	5,010
Depletion-adjusted offshore GDP (million USD)	2,400	2,550	2,670	2,820	3,060
Transition metrics					
Renewable share of offshore energy assets (%)	11%	14%	18%	23%	29%

Indicator	2020	2021	2022	2023	2024
Renewable share of offshore energy production (%)	8%	11%	14%	16%	20%

¶2 **Key insights from integrated accounts:**

1. ¶3
   Asset composition shift: The renewable share of offshore energy assets increased from 11% in 2020 to 29% in 2024. Oil nonetheless still accounts for 71% of asset value.
2. ¶4
   Depletion impact on NDP: Oil depletion averaged USD 1,900 million per year over 2020-2024. Deduction of depletion reduces offshore energy's contribution to GDP by 41% on average over 2020-2024 (from USD 5,010 million to USD 3,060 million in 2024, a 39% reduction in 2024 specifically). This adjustment reveals that conventional GDP overstates sustainable income from offshore energy by not accounting for resource depletion.
3. ¶5
   Pace toward 2030 targets: Offshore wind capacity grew from 2,100 MW in 2020 to 5,470 MW in 2024 (average addition of 842 MW/year). To reach the 10,000 MW target by 2030 requires adding 4,530 MW over six years, or 755 MW/year. The current pace is slightly above target, suggesting the 2030 goal is achievable.
4. ¶6
   Total offshore energy wealth: Despite oil depletion, total offshore energy asset value increased from USD 35,300 million (2020) to USD 38,380 million (2024), driven by renewable energy expansion. The figures indicate that the energy transition can maintain or increase natural capital value even as fossil resources are depleted.

3.7.7 Cross-stack integration

¶1 The offshore energy accounts developed in this example feed into broader ocean accounting and policy frameworks:

¶2 **Upward to policy (Section 1 circulars):**

- ¶3 **TG-1.1 National Ocean Budgets** – Total offshore energy asset value (USD 38.4 billion in 2024) appears on the ocean natural capital balance sheet, informing budget allocation decisions
- ¶4 **TG-2.5 Structure and Function of the Ocean Economy** – Offshore energy contribution to ocean GDP (USD 5.0 billion gross, USD 3.1 billion depletion-adjusted) contributes to measuring ocean economy size
- ¶5 **TG-2.1 Aggregate Biophysical Indicators of Environmental State** – Energy transition metrics (renewable share of assets, renewable share of production) track progress toward net zero targets

¶6 **Downward to data (Section 4 circulars):**

- ¶7 **TG-4.3 Administrative Data Sources** – Oil production data sourced from petroleum licensing authority, and offshore wind capacity from transmission system operator registers
- ¶8 **TG-4.1 Remote Sensing and Geospatial Data** – Lease area boundaries and BSU assignments enable spatial disaggregation of energy accounts

¶9 **Lateral to other accounts (Section 3 circulars):**

- ¶10 **TG-3.3 Economic Activity Relevant to the Ocean** – Offshore oil extraction (ISIC 0610) and offshore wind generation (ISIC 3510) classified within ocean economy
- ¶11 **TG-3.4 Flows from Economy to Environment** – Oil and gas extraction generated 4.2 million tonnes CO2-equivalent emissions in 2024, attributed to marine spatial units where platforms operate

DRAFT

Implementation Considerations

¶1 For minimum institutional capacity, data infrastructure, and human skills requirements for compiling these accounts, see TG-0.8 Implementation Readiness Assessment. For guidance on adapting these methods to sub-national scales, see TG-3.11 Sub-National Ocean Accounts.

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

5. References

1. ¶1 United Nations. (2025). *System of National Accounts 2025*, para. 11.200. Renewable energy resources (AN322) are formally recognised as assets "consisting of energy resources which comprise the cumulative quantities of kinetic, radiative and thermal energy recoverable from moving water (hydro and ocean energy), moving air (wind energy), hot underground and surface rock and water (geothermal resources) and incident solar radiation (solar resources)."
2. ¶2 2025 SNA, para. 1.25: "Natural resources are identified as a separate category within the asset classification, and renewable energy resources are explicitly recognised."
3. ¶3 United Nations. (2019). *System of Environmental-Economic Accounting for Energy (SEEA Energy)*, para. 5.8: "In SEEA-Energy, renewable sources of energy such as wind, solar and hydropower are not considered physical assets. … [T]here is no physical stock of these types of renewable sources of energy that can be used up or sold."
4. ¶4 2025 SNA, para. 11.182: "In the integrated framework of national accounts, natural resources are broken down into five asset categories: (i) land; (ii) mineral and energy resources; (iii) biological resources; (iv) water resources; and (v) other natural resources."
5. ¶5 2025 SNA, para. 11.199: "The first group of mineral and energy resources consists of non-renewable mineral and energy reserves (AN321) which consist of known deposits of non-renewable oil resources, natural gas resources, coal and peat resources, non-metallic minerals and metallic minerals located on or below the Earth's surface that are economically exploitable, given current technology and relative prices."
6. ¶6 2025 SNA, para. 11.200; see also Glossary entry for "Renewable energy resources" (AN322).
7. ¶7 2025 SNA, para. 11.202.
8. ¶8 2025 SNA, para. 11.200.
9. ¶9 United Nations. (2014). *System of Environmental-Economic Accounting 2012—Central Framework*, para. 5.231.
0. ¶10 2025 SNA, para. 11.165-11.168; see also Chapter 27 on Contracts, leases, licenses and permits.
1. ¶11 2025 SNA, para. 11.192.
2. ¶12 SEEA Central Framework (2012), paras. 5.407-5.410; see also TG-3.1 for the distinction between cultivated and natural aquatic resources.
3. ¶13 SEEA Energy (2019), para. 5.8; SEEA CF (2012), para. 2.50: "Energy from renewable sources represents a special case, inasmuch as renewable sources used in the generation of energy are different from non-renewable natural inputs, such as oil, as regards the manner in which they are exhausted."
4. ¶14 SEEA Central Framework (2012), paras. 5.216-5.224.
5. ¶15 2025 SNA, Annex 4, para. A4.59.
6. ¶16 SEEA Energy (2019), para. 5.8.
7. ¶17 SEEA Central Framework (2012), Section 5.4; SEEA Energy (2019), Chapter VI.
8. ¶18 SEEA Central Framework (2012), para. 5.228.
9. ¶19 See TG-0.1 for the Basic Spatial Unit framework for Ocean Accounts.
0. ¶20 2025 SNA classification AN3223 (Water energy resources).
1. ¶21 United Nations. (2017). *Framework for the Development of Environment Statistics (FDES 2013)*, para. 3.95: "Renewable energy includes solar (photovoltaic and thermal), hydroelectric, geothermal, tidal action, wave action, marine (non-tidal currents, temperature differences and salinity gradients), wind and biomass energy."
2. ¶22 SEEA Energy (2019), Table 5.1, based on UNFC-2009 categories.
3. ¶23 2025 SNA, para. 11.199.
4. ¶24 SEEA Energy (2019), paras. 5.11-5.12; UNECE (2010), *United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009*.
5. ¶25 SEEA Energy (2019), paras. 5.14-5.15; Table 5.1.
6. ¶26 SEEA Central Framework (2012), para. 5.193: "It is therefore recommended that valuation be undertaken only for deposits in class A: Commercially recoverable resources."
7. ¶27 SEEA Energy (2019), Table 5.3.
8. ¶28 SEEA Central Framework (2012), para. 5.194: "Because there are few transactions in mineral and energy resources in situ, the valuation of these assets requires the use of NPV approaches."

DRAFT

9. ¶29 SEEA Central Framework (2012), para. 5.199.
0. ¶30 SEEA Central Framework (2012), paras. 5.212-5.213.
1. ¶31 SEEA Energy (2019), para. 5.29: "In physical terms, the depletion of mineral and energy resources is equal to the quantity of the resource that is extracted."
2. ¶32 2025 SNA, Annex 4, para. A4.59.
3. ¶33 SEEA Central Framework (2012), paras. 5.216-5.224.
4. ¶34 SEEA Central Framework (2012), paras. 4.194-4.197.
5. ¶35 SEEA Central Framework (2012), paras. 4.200-4.201.
6. ¶36 2025 SNA, Glossary entry for "Terminal costs".
7. ¶37 SEEA Central Framework (2012), para. 4.202.
8. ¶38 Bull, A.S. and Love, M.S. (2020). 'Worldwide oil and gas platform decommissioning: A review of practices and reefing options'. *Ocean and Coastal Management* 168: 274-306.
9. ¶39 United Nations. (2021). *System of Environmental-Economic Accounting–Ecosystem Accounting (SEEA EA)*, Chapter 3, paras. 3.13-3.18, on criteria for delineating ecosystem assets.

DRAFT

Sub-National Ocean Accounts

Compiles ocean accounts at sub-national scales—provinces, municipalities.

Version 0.6.3 **Status** Draft **Stability** Emerging

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

CONTENTS

1. Outcome 3
2. Requirements 4
3. Guidance Material 4
3.1 Sub-National Spatial Delineation 5
3.2 Regionalisation of National Supply-Use Tables 8
3.3 Provincial/Local Asset Accounts and Ecosystem Extent/Condition 13
3.4 Enterprise-Level Attribution from National Totals 18
3.5 Linking Sub-National Accounts to Local Planning 18
3.6 Dashboard Design for Local Decision-Makers 20
Implementation Considerations 24
4. Acknowledgements 24
5. References 24

ABOUT THIS SPACE PAR

RECOMMENDED CITATION
Sub-National Ocean Accounts (2026) (GOAP Technical Guidance on Ocean Accounting, TG-3.11, v0.6.5). GOAP Secretariat. https://guidance.oceanaccounts.org/sections/local-v3/sub-national/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

OUTCOME

After completing this Circular, readers will be able to compile ocean accounts at sub-national scales—provinces, municipalities, marine parks, coastal zones, and other administrative or ecological regions below the national level. The Circular serves as the centralised reference for sub-national applicability across all ocean account types, addressing the spatial delineation of sub-national accounting areas, regionalisation of national supply-use tables, the compilation of ecosystem extent and condition accounts at local scales, and the design of information products for local decision-makers.

Section 3.4 extends the same disaggregation logic one step further, to enterprise-level attribution: expressing a single firm's dependence on, or contribution to, the totals for the area it operates in, which is what corporate reporting under TNFD, IFRS S1 and CSRD requires (TG-1.11 OA and the Private Sector Section 3.5).

Sub-national ocean accounts respond to a basic reality of ocean governance: most management decisions affecting marine and coastal resources are taken at the local or regional level. Marine spatial plans, fisheries access arrangements, coastal development permits, pollution discharge licences, and protected area management plans are typically the responsibility of sub-national authorities—provincial governments, municipal councils, port authorities, or marine park agencies. These authorities require accounting information that is spatially relevant to their jurisdiction. National aggregates obscure local variation and do not meet this need.

Key decision use cases enabled by sub-national ocean accounts include:

Provincial and municipal coastal planning: Sub-national governments responsible for coastal zones require integrated data on ecosystem extent, condition, economic activity, and pressures within their jurisdiction. A provincial governor managing a coastline with competing uses—tourism, fishing, aquaculture, port development—needs accounts that record how these activities interact with local ecosystems and what trade-offs are involved. Sub-national ecosystem extent and condition accounts provide the evidence base for zoning decisions and development control (see TG-1.2 Marine Spatial Planning).

Marine protected area management: Park managers require detailed accounts of ecosystem assets within their boundaries, including extent and condition changes, ecosystem service flows, and the economic activities of surrounding communities that depend on or affect the protected area. Sub-national accounts enable adaptive management by tracking whether conservation interventions are maintaining or improving ecosystem condition (see TG-1.3 Marine Spatial Management).

Local economic development planning: Municipal and regional authorities seeking to develop sustainable ocean economies require information on the structure and performance of ocean-related industries in their area, the natural capital base supporting those industries, and the distributional consequences of resource use for local populations (see TG-1.10 National Planning).

Integrated coastal zone management: Authorities responsible for managing the land-sea interface need accounts that capture upstream-downstream relationships between terrestrial catchments and marine receiving waters, linking land-use change, nutrient runoff, and coastal ecosystem condition at scales relevant to management intervention (see TG-2.7 Pollution and Other Flows to Environment).

This Circular addresses the delineation of sub-national spatial units (Section 3.1), methods for regionalising national supply-use tables (Section 3.2), a sub-national applicability matrix for all account types (Section 3.3), approaches to linking sub-national accounts to local planning processes (Section 3.5), and the design of dashboards and information products for local decision-makers (Section 3.6).

DRAFT

1. Outcome

¶1 After completing this Circular, readers will be able to compile ocean accounts at sub-national scales—provinces, municipalities, marine parks, coastal zones, and other administrative or ecological regions below the national level. The Circular serves as the centralised reference for sub-national applicability across all ocean account types, addressing the spatial delineation of sub-national accounting areas, regionalisation of national supply-use tables, the compilation of ecosystem extent and condition accounts at local scales, and the design of information products for local decision-makers.

¶2 Section 3.4 extends the same disaggregation logic one step further, to enterprise-level attribution: expressing a single firm's dependence on, or contribution to, the totals for the area it operates in, which is what corporate reporting under TNFD, IFRS S1 and CSRD requires (**TG-1.11 OA and the Private Sector** Section 3.5).

¶3 Sub-national ocean accounts respond to a basic reality of ocean governance: most management decisions affecting marine and coastal resources are taken at the local or regional level. Marine spatial plans, fisheries access arrangements, coastal development permits, pollution discharge licences, and protected area management plans are typically the responsibility of sub-national authorities—provincial governments, municipal councils, port authorities, or marine park agencies. These authorities require accounting information that is spatially relevant to their jurisdiction. National aggregates obscure local variation and do not meet this need.

¶4 **Key decision use cases** enabled by sub-national ocean accounts include:

¶5 **Provincial and municipal coastal planning**: Sub-national governments responsible for coastal zones require integrated data on ecosystem extent, condition, economic activity, and pressures within their jurisdiction. A provincial governor managing a coastline with competing uses—tourism, fishing, aquaculture, port development—needs accounts that record how these activities interact with local ecosystems and what trade-offs are involved. Sub-national ecosystem extent and condition accounts provide the evidence base for zoning decisions and development control (see **TG-1.2 Marine Spatial Planning**).

¶6 **Marine protected area management**: Park managers require detailed accounts of ecosystem assets within their boundaries, including extent and condition changes, ecosystem service flows, and the economic activities of surrounding communities that depend on or affect the protected area. Sub-national accounts enable adaptive management by tracking whether conservation interventions are maintaining or improving ecosystem condition (see **TG-1.3 Marine Spatial Management**).

¶7 **Local economic development planning**: Municipal and regional authorities seeking to develop sustainable ocean economies require information on the structure and performance of ocean-related industries in their area, the natural capital base supporting those industries, and the distributional consequences of resource use for local populations (see **TG-1.10 National Planning**).

¶8 **Integrated coastal zone management**: Authorities responsible for managing the land-sea interface need accounts that capture upstream-downstream relationships between terrestrial catchments and marine receiving waters, linking land-use change, nutrient runoff, and coastal ecosystem condition at scales relevant to management intervention (see **TG-2.7 Pollution and Other Flows to Environment**).

¶9 This Circular addresses the delineation of sub-national spatial units (Section 3.1), methods for regionalising national supply-use tables (Section 3.2), a sub-national applicability matrix for all account types (Section 3.3), approaches to linking sub-national accounts to local planning processes (Section 3.5), and the design of dashboards and information products for local decision-makers (Section 3.6).

DRAFT

2. Requirements

¶1 **Essential prerequisites:**

- ¶2 **TG-0.1 General Introduction to Ocean Accounts**: conceptual framework and the definition of the ocean accounting area
- ¶3 **TG-3.1 Asset Accounts**: methodology of physical and monetary asset accounts, including ecosystem extent and condition accounts
- ¶4 **TG-3.3 Economic Activity Relevant to the Ocean**: ocean economy thematic and extended accounting framework, including the ISIC-ocean economy concordance (Table 2)
- ¶5 **TG-3.8 Combined Presentations**: principles governing integration of multiple account types

¶6 **Helpful background:**

- ¶7 **TG-4.1 Remote Sensing and Geospatial Data**: satellite-based methods of measuring ecosystem extent at fine spatial resolution

¶8 **Framework Position**

¶9 This Circular addresses the spatial disaggregation of all ocean account components to sub-national scales. Sub-national accounts do not introduce new accounting relationships. Rather, they apply the same eleven relationships (E1–E11) identified in the Ocean Accounts Framework to geographically smaller units. Among the eleven edges, the following are most directly relevant at sub-national scale (see TG-0.1 Figure 0.1.2)[1]:

Edge	Direction	Relevance to Sub-National Accounts
Scope. TG-3.11 owns the spatial disaggregation of accounts compiled at national scale: boundary delineation, regionalisation methods, allocation keys, and which account types survive disaggregation. It introduces no new account, and cross-refers to the circular that owns each account for its structure.		

¶10 | E3 | FG1 to SG1 | Regional economic flows interacting with produced assets | | E9 | SG3 to FG1 | Local ecosystem services supplying sub-national economies | | E1 | FG1 to SG3 | Residual flows from regional industries to local ecosystems | | E11 | FG3 to SG3 | Intermediate ecosystem services within sub-national areas |

¶11 Edge directions follow the TG-0.1 Figure 0.1.2 convention. The textual "to" form is used in place of arrow symbols to ensure consistent rendering across the Observable site and PDF export.

DRAFT

3. Guidance Material

¶1 The SEEA Ecosystem Accounting framework establishes that accounting principles are equally applicable across different spatial scales and entities[2]. For any given thematic accounting exercise, there is no a priori restriction on the geographical area, type of entity, or classification that must be applied. Choices of spatial scope should be made with a focus on the use of the accounts, including the potential to compare results over time and in different locations[2]. This principle provides the foundation for sub-national ocean accounts: the same accounting structures used at national level—extent accounts, condition accounts, supply-use tables, asset accounts—can be compiled for provinces, municipalities, marine parks, or any other spatially delineated sub-national unit.

¶2 Sub-national compilation introduces specific methodological challenges that do not arise, or arise less acutely, at national level. These include the delineation of spatial units that serve both ecological and administrative purposes, the allocation of economic activity to sub-national areas when enterprises operate across boundaries, the treatment of cross-boundary ecosystem service flows, and the reconciliation of sub-national accounts with national totals. This section addresses each of these challenges in turn, drawing on the spatial accounting framework of SEEA EA Chapters 3 through 7 and the regionalisation methods developed through the EU Integrated System for Natural Capital Accounting (INCA) programme.

¶3 The EU INCA programme has demonstrated that national ecosystem accounts can be compiled from spatially explicit data at fine resolution (typically 100 m grid cells) and then aggregated to any administrative or ecological boundary [3]. This bottom-up approach, in which accounts are first compiled at fine spatial resolution and then aggregated upwards, is particularly well suited to sub-national ocean accounting because marine and coastal ecosystems rarely align with administrative boundaries. A coral reef system may span multiple municipal jurisdictions. A mangrove forest may straddle a provincial boundary, and a fish stock may range across the exclusive economic zones of several sub-national management authorities.

3.1 Sub-National Spatial Delineation

¶1 The first step in compiling sub-national ocean accounts is defining the spatial units for which accounts will be compiled. The SEEA EA identifies two fundamental spatial concepts: the ecosystem accounting area (EAA), which defines the total geographical scope, and the basic spatial unit (BSU), which is the smallest unit for which data are compiled [4]. At the national level, the EAA typically corresponds to the national territory plus the Exclusive Economic Zone. For sub-national accounts, the EAA is a portion of this national area, and the BSU is defined at a resolution appropriate to the management questions being addressed.

Defining sub-national accounting areas

¶1 Sub-national accounting areas should be delineated according to three criteria, balancing ecological coherence, administrative relevance, and data availability:

¶2 **Administrative boundaries** provide the most immediately useful delineation for sub-national accounts because they correspond to the jurisdictions of the decision-makers who will use the accounts. Provincial boundaries, municipal boundaries, coastal management zones, and marine protected area boundaries all serve as potential sub-national accounting areas. The SEEA EA notes that choices of geographical area should be made with a focus on the use of the accounts [2], and administrative boundaries maximise the alignment between accounting information and decision-making authority. Whilst they serve decision-making authority well, they rarely coincide with ecosystem boundaries, which can create challenges for measuring ecosystem extent and condition.

¶3 **Ecological boundaries** delineate areas based on ecosystem characteristics—bioregions, catchment-to-coast systems, large marine ecosystems, or habitat complexes. The IUCN Global Ecosystem Typology provides a hierarchical classification that can be used to define ecologically meaningful sub-national units for marine areas [5]. Ecological boundaries are particularly relevant when the management question concerns ecosystem-level processes (such as nutrient cycling, fish recruitment, or coastal protection) that operate independently of administrative divisions. The EU INCA programme adopted the river basin district as a key ecological boundary for freshwater accounts. Ecological units can therefore be used alongside administrative units [3].

¶4 **Hybrid boundaries** combine administrative and ecological criteria. For example, a sub-national accounting area might be defined as a province's coastal zone, extending from the provincial boundary inland to include the coastal catchment and seaward to include the nearshore marine area. This approach is particularly useful for integrated coastal zone management, where the management unit spans the land-sea interface. The SEEA EA describes how ecosystem accounting areas can be defined to suit particular analytical purposes, provided that the boundaries are clearly documented and consistently applied [6].

¶5 *Table 3.11.1: Comparison of spatial delineation approaches for sub-national ocean accounts*

DRAFT

Approach	Definition	Strengths	Limitations	Suitable Use Cases
Administrative	Provincial, municipal, or other jurisdictional boundaries	Aligns with decision-making authority; data often collected by jurisdiction	Ecosystems cross boundaries; marine areas may be poorly defined	Provincial economic accounts, municipal planning
Ecological	Bioregions, catchment-coast systems, large marine ecosystems	Captures ecosystem processes; supports ecological analysis	May not align with governance; economic data harder to allocate	Marine park management, ecosystem condition monitoring
Hybrid	Combining administrative and ecological criteria (e.g., provincial coastal zone)	Balances governance relevance with ecological coherence	Requires concordance with both administrative and ecological datasets	Integrated coastal zone management, marine spatial planning
Grid-based	Regular spatial grid (e.g., 1 km, 10 km cells)	Resolution-independent; supports aggregation to any boundary	No intrinsic meaning; requires overlay with both ecological and administrative units	Bottom-up compilation, remote sensing analysis

Basic spatial units for marine and coastal areas

¶1 The BSU is the smallest spatial unit at which ecosystem accounting data are compiled. For terrestrial ecosystem accounts, the EU INCA programme used grid cells of 100 m resolution, aggregated to 1 km reporting grids [3]. For marine and coastal sub-national accounts, the choice of BSU depends on the resolution of available data and the scale of the management questions being addressed. The SEEA EA does not prescribe specific grid sizes. The following implementation levels are indicative and should be aligned with the implementation readiness tiers established in **TG-0.8 Implementation Readiness Assessment**:

¶2 For coastal ecosystems (mangroves, seagrass meadows, coral reefs, salt marshes), remote sensing data from satellite platforms such as Sentinel-2 and Landsat provide spatial resolution of 10–30 m, enabling BSUs of 100 m to 1 km to be defined for extent mapping (see **TG-4.1 Remote Sensing and Geospatial Data**). For offshore areas where ecosystem type is inferred from bathymetry, substrate, and oceanographic conditions rather than direct observation, larger BSUs (1–10 km) may be appropriate. For pelagic environments, where ecosystem boundaries are dynamic and determined by water mass characteristics, even larger BSUs or feature-based delineation may be needed (see **TG-6.5 Pelagic and Open Ocean Accounts**).

¶3 The critical requirement is that BSUs can be aggregated consistently to any sub-national accounting area of interest. When accounts are compiled at fine spatial resolution using grid-based BSUs, they can be summed to administrative boundaries, ecological boundaries, or any hybrid unit, provided that spatial overlay procedures are applied consistently [7]. The SEEA EA emphasises that the choice of BSU should support the derivation of extent accounts, condition accounts, and ecosystem service flow accounts at the relevant spatial scale [7].

¶4 For practical implementation, compilers should consider the following indicative implementation levels (these are not authoritative thresholds but reflect the available spatial data infrastructure at different capacity levels):

- ¶5 **Implementation Level 1 (coarse)**: Sub-national accounting areas defined by existing administrative boundaries (provinces, municipalities), with ecosystem type mapped at 1 km resolution from global datasets (e.g., Global Mangrove Watch, Allen Coral Atlas). Suitable for initial compilations and countries with limited spatial data capacity. Corresponds broadly to TG-0.8 Level 1 readiness [8].

DRAFT

- ¶6 **Implementation Level 2 (moderate)**: Sub-national accounting areas combining administrative and ecological boundaries, with ecosystem type mapped at 100 m–1 km resolution from national or regional remote sensing programmes. Supports condition indicators derived from remote sensing. Corresponds broadly to TG-0.8 Level 2 readiness [8].
- ¶7 **Implementation Level 3 (fine)**: Grid-based BSUs at 100 m resolution or finer, enabling flexible aggregation to any boundary. Requires a well-developed spatial data infrastructure and is consistent with the EU INCA methodology [3]. Corresponds broadly to TG-0.8 Level 3 or Level 4 readiness [8].

Cross-boundary issues

¶1 Sub-national accounting areas inevitably encounter ecosystems, economic activities, mobile environmental assets, and environmental flows that cross their boundaries. Compilers must establish conventions for handling these cross-boundary issues to ensure that sub-national accounts are internally consistent and that they aggregate correctly to national totals.

¶2 **Ecosystem assets spanning boundaries**: When an ecosystem asset (e.g., a coral reef system or a mangrove forest) spans two sub-national accounting areas, the asset should be allocated to each area based on the physical extent within that area's boundary. This is conceptually straightforward for extent accounts (area in km² within each jurisdiction) but more complex for condition accounts, where a single condition indicator may apply to the ecosystem as a whole rather than to the portion within each jurisdiction. The preferred approach is to compile condition indicators for the BSUs falling within each accounting area and to aggregate these to the accounting area level, recognising that the condition of a cross-boundary ecosystem may differ between the portions in different jurisdictions.

¶3 **Economic activities spanning boundaries**: Enterprises may operate across multiple sub-national areas—a fishing fleet based in one province may harvest in waters managed by another. The SEEA CF and the 2025 SNA apply the residence principle, allocating economic activity to the area where the enterprise is resident [9]. For sub-national accounts, this means that the gross value added of a fishing enterprise is allocated to the province where the enterprise is registered, even if fishing takes place in another province's waters. Physical catch, in contrast, is recorded where extraction physically occurs. This produces two sub-national records with different geographic logic for the same industry: residence-based GVA and territory-based catch. Compilers should clearly document which view appears in each account and dashboard product, and include a memo item recording the cross-boundary share to prevent users from inadvertently summing the two records as though they refer to the same province (see **TG-3.3 Economic Activity Relevant to the Ocean**).

> ¶4 **Worked example: cross-boundary fleet**
> ¶5 A province-A-registered fishing enterprise extracts 800 tonnes from province-B waters.
> - ¶6 **Province A economic accounts:** GVA attributed by residence = USD 1.2 M
> - ¶7 **Province B physical accounts:** catch by territory = 800 t
>
> ¶8 Both records are correct and complementary. They should not be summed to infer a single provincial total.
> ¶9 The cross-boundary memo item reads: "Province A resident fleet operating in province B: 800 t (territory) / USD 1.2 M GVA (residence)."

¶10 **Mobile individual environmental assets**: Mobile environmental assets such as fish stocks pose particular allocation challenges because stock boundaries rarely align with administrative areas (see Table 3.11.4). Two candidate allocation conventions are available for sub-national fish-stock asset accounts: (i) a **historical catch share** convention, allocating the stock biomass across sub-national areas in proportion to their multi-year average share of total landings from the stock, and (ii) a **jurisdictional water area** convention, allocating in proportion to the area of each sub-national jurisdiction's waters falling within the stock's assessment range. The recommended default is the jurisdictional water area convention where stock-range maps are available, because it ties the asset record to the underlying spatial extent of the stock rather than to historical extractive performance.

DRAFT

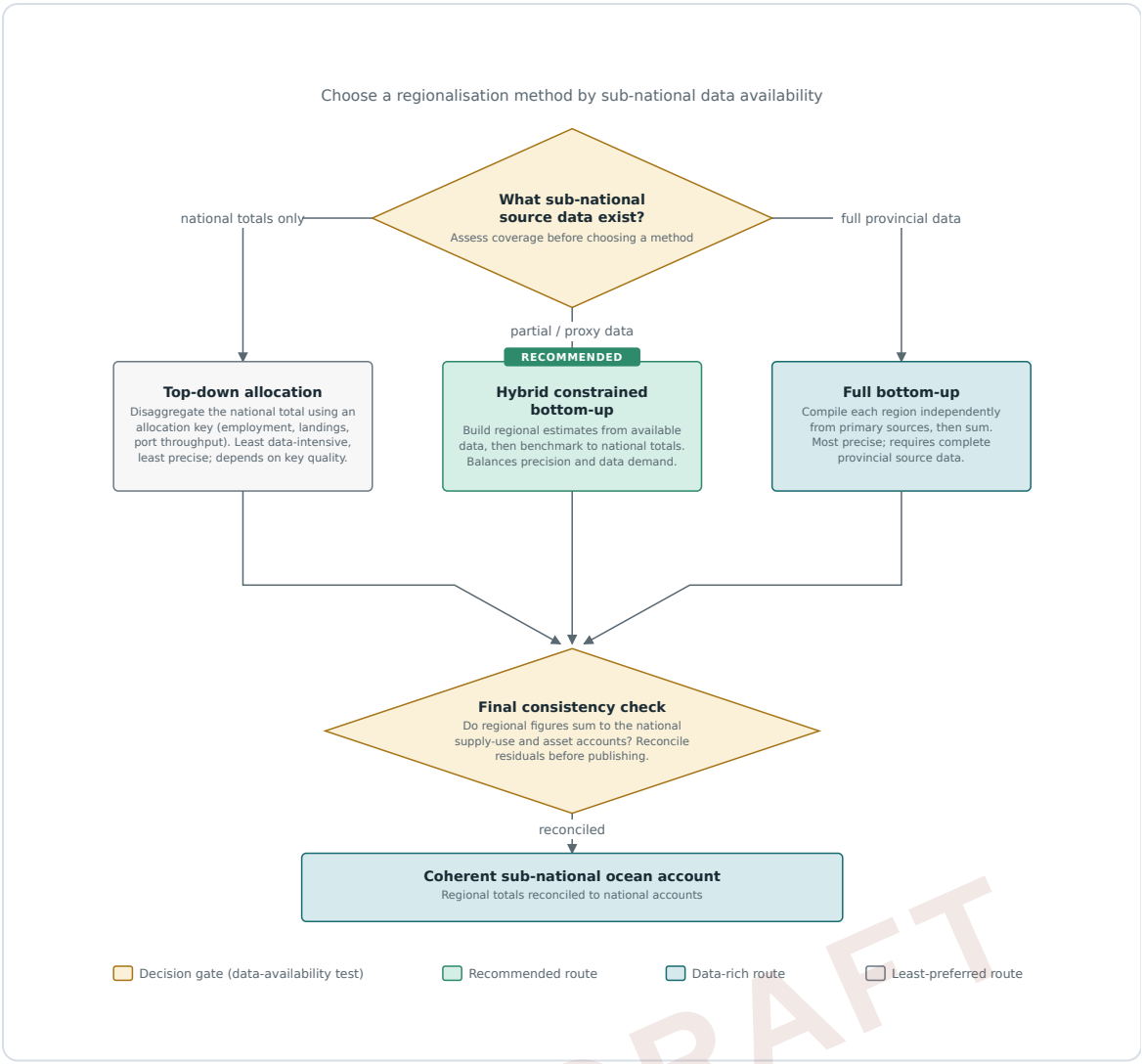
Historical catch share should be used as a fallback when only landings data exist. All sub-national jurisdictions sharing a single stock must adopt the same convention, coordinated by the national compiler, so that sub-national asset records aggregate to a single national stock biomass without overlap or residual. Both conventions should reference the stock-assessment-unit conventions in **TG-6.7 Fisheries Stock Assessment**. For highly mobile pelagic stocks, the asset account may be best held at national level only, with sub-national accounts limited to catch and value flows allocated under the residence/territory rules above.

¶11 **Ecosystem service flows across boundaries**: Many marine ecosystem services benefit areas beyond the ecosystem's location. Coastal protection services from a mangrove forest in one municipality may protect infrastructure in an adjacent municipality. Carbon sequestration services benefit the global community. For sub-national accounts, compilers should record supply in the accounting area where the ecosystem is located and use in the area where the beneficiary resides, following SEEA EA Chapter 7. For global-public-good services such as carbon sequestration and biodiversity option values, where the beneficiary is the global community rather than any identifiable sub-national unit, allocate the use side to a Rest of World column in the sub-national use table. This treatment mirrors the SEEA EA handling of carbon sequestration as a service with a Rest of World beneficiary and ensures that sub-national use accounts can be summed to national totals without generating spurious residuals (see **TG-3.2 Flows from Environment to Economy**)[10].

3.2 Regionalisation of National Supply-Use Tables

¶1 Regionalisation is the process of disaggregating national-level economic accounts into sub-national units. For ocean accounts, the primary target of regionalisation is the ocean economy supply-use table compiled following the guidance in **TG-3.3 Economic Activity Relevant to the Ocean**. Regionalisation enables sub-national authorities to understand the structure and scale of ocean economic activity within their jurisdiction. The choice between top-down, hybrid, and bottom-up regionalisation turns on what sub-national source data exist, with all three routes converging on a consistency check against national totals (Figure 3.11.1).

DRAFT



DRAFT

Figure 3.11.1 Sub-national ocean-account regionalisation is chosen by one gate: what sub-national source data exist? Routes are top-down proxy, hybrid constrained bottom-up (recommended), or full bottom-up; all end in a national consistency check.

Source: TG-3.11 draft, §3.2 (Regionalisation of National Supply-Use Tables).

Adapted from: SEEA EA 2024, §10.7–10.30 (sub-national ecosystem accounting), for the top-down / bottom-up method taxonomy.

Approaches to regionalisation

¶1 Three approaches to regionalisation are established in the regional accounting literature, each with different data requirements and precision levels:

¶2 **Top-down allocation** distributes national totals to sub-national units using allocation keys—proxy indicators that approximate the spatial distribution of economic activity. Common allocation keys for ocean economy accounts include:

- ¶3 Employment by industry and region (from labour force surveys or census data)
- ¶4 Number of enterprises by industry and region (from business registers)
- ¶5 Port throughput (for maritime transport industries)
- ¶6 Fisheries landings by port (for commercial fishing industries)
- ¶7 Tourist overnight stays by region (for coastal tourism industries)
- ¶8 Aquaculture production by region (for aquaculture industries)

¶9 For capital-intensive ocean industries (offshore oil and gas, port operations, shipbuilding), labour-based allocation keys may misallocate value added because labour productivity varies

across sub-national areas. Where independent regional GVA estimates are available for any industry—even partial or preliminary estimates from administrative sources—compilers should run a diagnostic comparison of implied regional labour productivity against the top-down assumption before finalising allocations. Where bottom-up industry totals do not match the national constraint, apply a proportional residual reallocation (or an RAS balancing procedure for full matrix reconciliation) and document the adjustment [11].

¶10 The advantage of top-down allocation is that it ensures consistency with national totals: in the pure top-down case, sub-national values sum exactly to the national figure. Once productivity adjustments or residual reallocations are applied, additivity is preserved through the documented balancing step. The disadvantage is that the accuracy of sub-national estimates depends on the quality of the allocation key.

¶11 **Bottom-up compilation** constructs sub-national accounts directly from regional data sources—regional business surveys, sub-national tax records, administrative data from provincial authorities. This approach can produce more accurate sub-national estimates but faces the challenge of ensuring consistency with national totals. The EU INCA programme adopted a bottom-up approach for ecosystem service accounts, compiling spatially explicit biophysical models at grid-cell level and aggregating to administrative boundaries [3]. For economic accounts, bottom-up compilation is feasible where sub-national statistical systems are well developed (see **TG-4.3 Administrative Data Sources**).

¶12 **Hybrid methods** combine top-down and bottom-up approaches. National totals from the SNA are allocated to sub-national units using bottom-up data as allocation keys. This approach ensures both consistency with national aggregates and use of the best available regional information. This approach is recommended by Eurostat for regional accounts and is well suited to ocean economy regionalisation [11].

¶13 Note that the §3.2 procedure produces an industry-by-region GVA and employment matrix (a regional industry account equivalent to a simplified supply-use view). It does not produce a full product-by-industry sub-national supply-use table (SUT). Table 3.11.4 (applicability matrix) rates full SUT sub-national feasibility as Low-Moderate for this reason. Compilers requiring a product-by-region dimension should consult Eurostat's *Manual of Regional Accounts Methods* and expand the procedure to include product allocation as a second stage [12].

¶14 *Table 3.11.2: Regionalisation methods for ocean economy supply-use tables*

Method	Data Requirements	Accuracy	National Consistency	Suitable Conditions
Top-down allocation	National SUT + regional allocation keys (employment, production)	Moderate — depends on allocation key quality	Guaranteed in pure top-down case	Limited sub-national data; initial compilation
Bottom-up compilation	Regional business surveys, tax records, administrative data	High — if data quality is adequate	Not guaranteed; requires balancing	Strong sub-national statistical systems
Hybrid (constrained bottom-up)	National SUT + regional data for key industries	High — combines local accuracy with national consistency	Achieved through documented balancing step	Intermediate data availability; recommended approach

Step-by-step regionalisation procedure

¶1 The following procedure describes how to regionalise national ocean economy supply-use tables for a set of sub-national areas (e.g., coastal provinces). This procedure assumes that a national ocean economy thematic account has already been compiled following **TG-3.3 Economic Activity Relevant to the Ocean**.

DRAFT

¶2 **Step 1: Define the sub-national areas.** Select the set of sub-national units for which ocean economy accounts will be compiled. These should correspond to the sub-national accounting areas defined in Section 3.1. Ensure that the union of all sub-national areas covers the national ocean accounting area without gaps or overlaps (for economic accounts, inland provinces without ocean frontage will have zero or near-zero ocean economy activity for most industries, but may have non-zero values for processing and trade industries).

¶3 **Step 2: Assemble regional allocation keys.** For each ocean-characteristic industry (as classified in **TG-3.3 Economic Activity Relevant to the Ocean**, Table 2, the ISIC-ocean economy concordance), identify the best available spatial indicator. Table 3.11.3 provides illustrative allocation keys for major ocean economy industries.

¶4 *Table 3.11.3: Illustrative allocation keys for ocean economy regionalisation*

Ocean Economy Industry	Type	Allocation Basis	Recommended Allocation Key	Data Source
Marine fishing (GVA)	Ocean-dependent	Residence	Enterprise register: GVA by province of registration	Business register, fisheries authority licensing
Marine fishing (physical catch)	Ocean-dependent	Territory	Fish landings value/volume by port	Fisheries authority landing records
Aquaculture	Ocean-dependent	Territory (= residence for fixed installations)	Aquaculture production value by region	Aquaculture licences and production surveys
Fish processing	Ocean-related	Establishment	Employment in fish processing by region	Labour force survey, business register
Coastal tourism	Ocean-related (partial)	Territory	Tourism expenditure or overnight stays by region (apply ocean-share ratio from TG-3.3 Table 2 before allocating)	Tourism satellite account, accommodation surveys
Maritime transport (GVA)	Ocean-dependent	Residence	Shipping operator register by province of registration	Maritime authority operator registry
Maritime transport (physical throughput)	Ocean-dependent	Territory	Port throughput (tonnage handled) by port	Port authority statistics
Offshore oil and gas	Ocean-related (partial)	Territory	Production value by field/block location (apply ocean-share ratio from TG-3.3 Table 2 before allocating)	Petroleum authority production data
Shipbuilding and repair	Ocean-related	Establishment	Employment in shipbuilding by region (apply ocean-share ratio from TG-3.3 Table 2 before allocating)	Business register
Coastal construction	Ocean-related (partial)	Establishment	Construction permits and value by coastal municipality (apply ocean-share ratio from TG-3.3 Table 2 before allocating)	Building permit records
Marine research (ocean-related)	Ocean-related (partial)	Establishment	Research expenditure by institution location (apply ocean-share ratio from TG-3.3 Table 2 before allocating)	Research funding databases

DRAFT

¶5 **Reconciling Table 3.11.3 with the §3.1 residence rule.** The "Allocation Basis" column reconciles Table 3.11.3 with the residence-vs-territory rule established in §3.1. For mobile-fleet industries (marine fishing, maritime transport), the table distinguishes residence-basis keys for GVA from territory-basis keys for physical activity, and compilers should populate both records following the worked example in §3.1. For fixed-installation industries (aquaculture, ports, offshore platforms, processing plants, shipyards), residence and establishment effectively coincide so a single allocation key suffices. For all industries classified as "Ocean-related (partial)" (including coastal tourism, offshore oil and gas, shipbuilding and repair, coastal construction, and marine research) the regional allocation key must be multiplied by the industry-specific ocean-share ratio from TG-3.3 Table 2 before applying the Step 3 formula, so that the regional total does not over-state ocean-economy activity by absorbing inland-attributable or non-ocean activity captured in the underlying expenditure, employment, or permit data.

¶6 **Step 3: Allocate national values.** For each industry, distribute the national supply-use table entries to sub-national areas in proportion to the allocation key. For a given industry *i* and sub-national area *r*, the allocated gross value added is:

¶7 $GVA(i,r) = GVA(i,national) \times Key(i,r) / Key(i,total)$

¶8 where $Key(i,r)$ is the allocation key value for industry *i* in area *r* and $Key(i,total)$ is the national total of the allocation key. For capital-intensive industries where an employment key is used, check whether implied regional labour productivity is broadly consistent with any available independent estimate. If bottom-up totals differ from the national constraint, apply a proportional residual reallocation and document the balancing step.

¶9 **Step 4: Balance and validate.** Check that sub-national values sum to national totals for each industry (if a product-dimension regionalisation is also undertaken as a separate stage, balance products on the supply and use sides separately). Where bottom-up data are available for specific industries (e.g., fisheries landings data are typically available by port), use these to validate or adjust the top-down allocations. Document any discrepancies and the adjustments made to resolve them. Apply the quality assurance procedures described in **TG-0.7 Quality Assurance Principles**.

¶10 **Step 5: Compile regional ocean economy indicators.** From the regionalised supply-use tables, derive sub-national ocean economy indicators including regional ocean economy GVA, ocean economy share of regional GDP, ocean economy employment by industry, and labour productivity by ocean industry. These indicators enable comparison across sub-national areas and identification of regional specialisation patterns (see **TG-2.5 Structure and Function of the Ocean Economy**). Note that derived ratios computed at this step (ocean economy share of regional GDP, labour productivity by industry, and other intensity measures) are not additive across sub-national areas. The area-weighted-mean treatment recommended in §3.5 for condition indices applies in principle to these economy ratios as well: a national ratio cannot be computed by simple summation of sub-national ratios and must be derived from the underlying levels.

Challenges and limitations

¶1 Regionalisation of ocean economy accounts faces several specific challenges that compilers should anticipate:

¶2 **Confidentiality constraints**: In small sub-national areas, individual enterprises may dominate particular industries, making it impossible to publish industry-level data without revealing individual enterprise information. Compilers may need to aggregate industries or suppress cells in sub-national tables to comply with statistical confidentiality requirements. This is particularly common for offshore energy, where a single installation may constitute the entire industry in a given sub-national area (see **TG-3.10 Offshore Energy Accounts**).

¶3 **Headquarters versus establishment allocation**: National accounts record economic activity at the enterprise level, which may be attributed to the headquarter location rather than the establish-

DRAFT

ment where production occurs. For ocean economy industries where the headquarter and the establishment are in different sub-national areas (e.g., a fishing company headquartered in the capital city but operating from a regional port), the allocation should ideally be to the establishment location. Business register data with establishment-level information support this allocation.

¶4 **Informal economy**: In many countries, much ocean economic activity occurs in the informal sector—small-scale fishing, informal coastal tourism, artisanal aquaculture. These activities are poorly captured in national accounts and even less visible in regional data. Where the national supply-use table is exhaustiveness-adjusted (i.e., it already includes an estimate of informal activity), sub-national accounts should regionalise the adjusted national total and document the informal component within the regional figure rather than adding informal estimates on top. Where the national table is not exhaustiveness-adjusted, add a supplementary informal-economy memo row at sub-national level rather than altering the regional total, to avoid breaking national consistency (see **TG-4.2 Survey Methods for Ocean Economic Activity**)[13].

¶5 **Temporal misalignment**: National supply-use tables and sub-national allocation keys may refer to different time periods or use different reference dates. Compilers should verify temporal alignment and adjust for any systematic biases introduced by timing differences, following the general guidance on temporal consistency in **TG-0.2 Overview of Relevant Statistical Standards**.

3.3 Provincial/Local Asset Accounts and Ecosystem Extent/Condition

¶1 This section provides the sub-national applicability matrix, a reference for determining which ocean account types can be compiled at sub-national scales, what spatial resolution is needed, and what specific considerations apply. The matrix is followed by detailed guidance on compiling ecosystem extent and condition accounts at sub-national scales, drawing on SEEA EA Chapters 4 and 5.

¶2 A unified illustrative entity is used throughout §3.3 and §3.5. From this version onward, the worked examples in Tables 3.11.5 (extent), 3.11.6 (condition), and 3.11.7 (dashboard) are all compiled for a single illustrative entity, the **Province X Coastal Zone** (an administrative composite accounting area combining the Province X coastal jurisdiction with the embedded Marine Park Y management area), spanning two accounting periods (2024–2025). Table 3.11.5 reports the extent account for the 2025 period (closing stock as at end-2025); Table 3.11.6 reports the condition account for the same entity using 2024–2025 paired observations from the Marine Park Y monitoring programme (which is the most data-rich subset of the Province X Coastal Zone); and Table 3.11.7 presents the integrated dashboard, whose indicator values are derived from these two upstream tables together with indicative three-year trends extrapolated from the same monitoring series. Where a dashboard indicator cannot be derived from Tables 3.11.5–3.11.6 (e.g., catch / sustainable yield, which requires a stock-assessment account not compiled in this worked example), the dashboard cell is marked "n/a — not illustrated" rather than populated with hypothetical values. Traceback from each dashboard cell to the underlying account table is provided in the "Account Source" column of Table 3.11.7.

Sub-national applicability matrix

¶1 The following matrix summarises the sub-national applicability of each account type covered by the Technical Guidance circulars.

¶2 *Table 3.11.4: Sub-national applicability matrix for ocean account types*

DRAFT

Account Type	TG Circular	Sub-National Feasibility	Minimum Spatial Resolution	Key Data Requirements	Special Considerations
Ecosystem extent	TG-3.1	High	100 m – 1 km grid	Remote sensing imagery, habitat maps	Can be compiled at any spatial scale where mapping data exist; grid-based approach supports flexible aggregation
Ecosystem condition	TG-3.1	High	1 – 10 km grid	In situ monitoring, remote sensing indices	Condition indicators may require local calibration; monitoring station density varies by region
Individual environmental assets (fish stocks)	TG-3.1, TG-6.7	Moderate	Stock assessment unit	Stock assessments, catch data by area	Stock boundaries rarely align with administrative areas; default allocation is the jurisdictional water area convention (historical catch share as fallback); all sharing jurisdictions must adopt the same convention coordinated by the national compiler. Full guidance in §3.1.
Individual environmental assets (minerals, energy)	TG-3.1, TG-3.10	High	Licence block / field	Production data by field or block	Data typically available at field level; confidentiality may limit publication
Ecosystem service flows (physical)	TG-3.2	High	100 m – 1 km grid	Biophysical models, land/sea cover maps	EU INCA methodology demonstrated at 100 m resolution; marine models available for key services. Global-public-good services (carbon sequestration, biodiversity option value) require Rest of World use allocation (see §3.1).
Ecosystem service flows (monetary)	TG-3.2, TG-1.9	Moderate	Ecosystem type / region	Valuation models, regional price data	Valuation parameters (unit values, discount rates) may need regional adjustment. Global-public-good services (carbon sequestration, biodiversity option value) require Rest of World use allocation (see §3.1).
Ocean economy GVA and employment	TG-3.3	Moderate	Province / municipality	Regional economic data, allocation keys	Requires regionalisation (Section 3.2); confidentiality constraints in small areas

DRAFT

Account Type	TG Circular	Sub-National Feasibility	Minimum Spatial Resolution	Key Data Requirements	Special Considerations
Supply-use tables	TG-3.3	Low-Moderate	Province (with caveats)	Regional production and trade data	The §3.2 procedure produces a regional industry account (GVA × region matrix), not a full product-by-industry SUT; the latter requires additional product-dimension regionalisation (see text)
Residual flows (pollution)	TG-3.4	High	Point source / catchment	Discharge permits, monitoring data, runoff models	Point-source data inherently spatial; diffuse pollution requires catchment modelling
Social accounts	TG-3.5	Moderate	Province / municipality	Household surveys, census data	Survey sample sizes may be insufficient for fine sub-national disaggregation
Traditional knowledge	TG-3.6	High	Community / cultural area	Community engagement, participatory mapping	Inherently local; community-based recording methods are well suited to sub-national compilation
Governance accounts	TG-3.7	High	Management area / jurisdiction	Legal instruments, management plans, MPA boundaries	Governance arrangements are typically defined at sub-national scales
Combined presentations	TG-3.8	High	Depends on component accounts	All relevant component accounts at sub-national level	Only as strong as the weakest component; partial compilations are valuable
Aquaculture accounts	TG-3.9	High	Licence / farm / region	Aquaculture production data, licence records	Production data typically available at farm or region level
Offshore energy accounts	TG-3.10	High	Licence block / field	Production and revenue data by field	Confidentiality is the main constraint, not spatial data availability

DRAFT

¶3 The matrix indicates that ecosystem-based accounts (extent, condition, ecosystem services, residual flows) generally have high sub-national feasibility because they are compiled from spatially explicit data sources—remote sensing, monitoring stations, biophysical models. Economic accounts present more challenges because the SNA recording conventions (residence-based, enterprise-level) do not always map easily to sub-national geography. Social accounts face sample-size constraints when disaggregated to small areas.

¶4 Compilers should use this matrix to plan a realistic scope for sub-national compilation. A pragmatic approach begins with the account types that have high sub-national feasibility (extent, condition, governance) and progressively adds more challenging account types (economic activity, social accounts) as data systems develop. This incremental approach is consistent with the implementation readiness guidance in **TG-0.8 Implementation Readiness**.

Ecosystem extent accounts at sub-national scale

¶1 Ecosystem extent accounts record the area of each ecosystem type within a defined accounting area, including additions and reductions during the accounting period [14] . At sub-national scales, extent accounts can be compiled at high spatial resolution using remote sensing data, providing detailed maps of ecosystem distribution and change that are directly useful for local planning and management.

¶2 The SEEA EA defines extent as the area of each ecosystem type, measured in consistent spatial units (typically hectares or square kilometres) [14] . For sub-national accounts, the compilation process follows the same structure as national extent accounts (see **TG-3.1 Asset Accounts**, Section 3.5.1) but operates at finer spatial resolution and within the boundaries of the sub-national accounting area.

¶3 Key considerations for sub-national extent accounts include:

¶4 **Ecosystem type classification at fine resolution**: The ecosystem type classification used for national accounts may need refinement for sub-national purposes. For example, a national extent account may record "coral reef" as a single ecosystem type, whereas a marine park manager may need to distinguish between fringing reefs, barrier reefs, and patch reefs. The IUCN Global Ecosystem Typology provides a hierarchical classification that supports this refinement—Level 3 (ecosystem functional groups) provides the national classification, whilst Level 4 or Level 5 (bio-geographic ecotypes or local ecosystem subgroups) can be used for sub-national detail [5] . Compilers should document the classification used and provide concordance tables linking sub-national types to the national classification.

¶5 **Change detection and attribution**: Sub-national extent accounts should record net change in ecosystem extent and identify the drivers of that change. At local scales, it is often possible to attribute extent changes to specific causes—land conversion for coastal development, aquaculture expansion into mangrove areas, storm damage to coral reefs, or restoration activities. Attributing changes to drivers strengthens the policy relevance of sub-national accounts by enabling targeted management responses. The EU INCA programme demonstrated change-attribution methods by overlaying land-cover change maps with land-use planning data [3] .

¶6 **Accounting for managed ecosystems**: Sub-national areas, particularly marine protected areas and coastal reserves, may contain ecosystems under active management or restoration. Extent accounts for these areas should distinguish between natural ecosystem extent and managed or restored extent, documenting the investment in ecological restoration as a form of ecosystem asset enhancement (see **TG-6.2 Mangrove and Coastal Wetland Accounting** for mangrove restoration accounting).

¶7 *Table 3.11.5: Illustrative sub-national ecosystem extent account (Province X Coastal Zone, 2024–2025)*

Ecosystem Type	Opening Extent (km²)	Managed Expansion	Natural Expansion	Managed Reduction	Conversion to Other Use	Net Change (km²)	C E (
Mangroves	85.2	+2.1	+0.3	0.0	-1.8	+0.6	8
Seagrass meadows	42.7	0.0	+0.1	0.0	-0.9	-0.8	4
Coral reefs	128.5	0.0	0.0	0.0	-0.2	-0.2	1
Salt marshes	18.3	+0.8	+0.1	0.0	-0.5	+0.4	1
Sandy shores	22.6	0.0	+0.2	0.0	-1.1	-0.9	2
Continental shelf waters	650.0	–	–	–	–	– [15]	6
Total (mapped ecosystems, excl. shelf – see [15])	**297.3**	**+2.9**	**+0.7**	**0.0**	**-4.5**	**-0.9**	**2**

DRAFT

Ecosystem Type	Opening Extent (km²)	Managed Expansion	Natural Expansion	Managed Reduction	Conversion to Other Use	Net Change (km²)	C E (
Total accounting area (incl. shelf, constant assumption)	**947.3**	**+2.9**	**+0.7**	**0.0**	**-4.5**	**-0.9**	**9**

Ecosystem condition accounts at sub-national scale

¶1 Ecosystem condition accounts record the quality or health of ecosystems using indicators that capture biotic and abiotic characteristics [16]. The SEEA EA organises condition indicators into six groups: physical state, chemical state, compositional state, structural state, functional state, and landscape-level characteristics [16]. At sub-national scales, condition accounts can draw on local monitoring data that may provide richer detail than national monitoring networks.

¶2 Sub-national condition accounts present both opportunities and challenges relative to national accounts:

¶3 **Opportunities**: Local monitoring programmes—conducted by marine park authorities, provincial environment agencies, university research stations, or citizen science programmes (see **TG-4.4 Citizen Science**)—often collect condition data at higher temporal and spatial resolution than national monitoring networks. Reef health surveys within marine protected areas, water quality monitoring at local stations, seagrass shoot density measurements by research teams, and bird counts by volunteer networks all provide condition data that can be incorporated into sub-national accounts. The integration of research data into accounting frameworks is addressed in **TG-4.5 Research Data**.

¶4 **Challenges**: Condition indicators require reference levels against which current condition is assessed. The SEEA EA recommends establishing reference condition based on the state of ecosystems at a specified reference time, in the absence of human influence, or at a level required to sustain a target level of ecosystem services [16]. At sub-national scales, reference condition may vary across the accounting area due to natural environmental gradients (e.g., reef condition naturally varies with depth, exposure, and latitude). Compilers should use spatially explicit reference conditions where possible, rather than applying a single national reference level across all sub-national areas.

¶5 *Table 3.11.6: Illustrative sub-national ecosystem condition account (Province X Coastal Zone — Marine Park Y subset, 2024–2025)*

Condition Indicator	Direction	Ecosystem Type	Unit	Upper Reference (VH)	Lower Reference (VL)	2024 Value	2025 Value
Live coral cover	Positive	Coral reefs	%	60	0	38	35
Water clarity (Secchi depth)	Positive	Coral reefs	metres	25	0	18	17
Seagrass shoot density	Positive	Seagrass meadows	shoots/m²	800	0	520	490
Canopy height	Positive	Mangroves	metres	12	0	8.5	8.7
Reef fish species richness [18]	Positive	Coral reefs	number	200	0	142	138
Nutrient concentration (DIN)	Negative	Coastal waters	ug/L	5	20	8.2	9.1

¶6 **Interpreting sub-national condition accounts**: The normalisation procedure for condition indicators (including positive- and negative-direction rescaling, bounding to [0, 1], and reference condition establishment) follows **TG-2.1 Biophysical Indicators for Ocean Accounts** Section 3.4.1.

DRAFT

The Δ Index column (closing minus opening rescaled index) is the headline accounting output for condition change, encoding direction automatically so that a negative Δ always denotes worsening condition regardless of whether the underlying raw indicator is positive- or negative-direction.

¶7 An aggregate condition index for each ecosystem type can be derived using an area-weighted mean of individual indicator indices as the default, where sub-units differ in extent. The aggregation operates within a single ecosystem type: indices for different ecosystem types (e.g., coral reefs and mangroves) are not pooled into a single composite without an explicit reweighting choice. For sub-national decision-makers, the disaggregated indicator-level data are often more useful than aggregate indices, as they point directly to the specific pressures requiring management intervention.

3.4 Enterprise-Level Attribution from National Totals

¶1 Sub-national disaggregation and enterprise-level attribution are the same problem at different grain. Sections 3.1 to 3.3 disaggregate national totals to an administrative or ecological area; corporate reporting under TNFD, IFRS S1 and CSRD requires the further step of expressing a single firm's dependence on, or contribution to, the totals for the area it operates in (**TG-1.11 OA and the Private Sector** Section 3.5).

¶2 **Spatial overlay is the starting point, not the answer.** A firm intersects its asset locations or sourcing geographies with the spatially disaggregated accounts to obtain area-level figures. The precision of the result is bounded by the resolution of the underlying compilation (**TG-2.12** Section 3.3), and an overlay performed without the reconciliation in Section 3.2 will produce site-level figures that do not sum to the national totals they were derived from. That failure is the principal reason corporate disclosures cannot be verified against national statistics, which is the value the accounts are supposed to supply.

¶3 **Attribution depends on the service type.** For provisioning services with established harvest or extraction reporting — commercial fisheries, aquaculture, aggregates — a firm's reported volume can be expressed as a proportion of total national extraction, and a corresponding share of the ecosystem service use attributed to it. For regulating and cultural services there is no equivalent reported quantity, and attribution rests on contribution analysis: expressing the firm's dependence on, or effect upon, an ecosystem function as a function of its physical presence and activity intensity at the relevant location. Contribution analysis is an approximation and should be reported as one.

¶4 **The accounts supply the denominator.** In both cases the national or area account provides the total against which a firm-level figure is expressed as a share. Compilers responding to enterprise requests should supply the denominator and its basis rather than a firm-specific figure, which the firm is better placed to compute and is responsible for.

¶5 Where sector guidance from the TNFD or methods from the Science Based Targets Network specify an attribution approach for a given realm, that approach takes precedence; this section covers the case where none is specified.

3.5 Linking Sub-National Accounts to Local Planning

¶1 Sub-national ocean accounts achieve their full value when they are integrated into local planning and decision-making processes. This requires institutional arrangements that connect the compilation of accounts to the governance processes that will use them, and analytical frameworks that translate accounting data into planning-relevant information.

Institutional arrangements for sub-national compilation

¶1 The compilation of sub-national ocean accounts requires coordination between national statistical offices (which compile national accounts and maintain statistical standards), sub-national government agencies (which hold local data and make local decisions), and specialised agencies (marine park authorities, fisheries agencies, port authorities) that operate at sub-national scales.

DRAFT

The SEEA EA notes that "much of the information required to compile ocean accounts is common to other communities of practice including those for marine spatial planning, disaster risk and climate change" and that "one objective of the ocean accounting community of practice is to ensure that these common data are standardized and shared" [20].

¶2 Effective institutional arrangements for sub-national compilation typically involve three elements. First, a national coordination body (often the national statistical office or a designated environment-economy accounting unit) establishes methodological standards and ensures that sub-national accounts are consistent with national accounts and with international standards. This coordination function is described in **TG-4.7 National Data Coordination Architectures**. Second, sub-national compilation teams, located within provincial statistical offices, coastal management authorities, or marine park agencies, assemble local data and compile accounts following the national methodology. Third, a data harmonisation process ensures that sub-national accounts use consistent classifications, reference periods, and measurement units, enabling aggregation to national totals and comparison across sub-national areas (see **TG-4.6 Data Harmonisation and Interoperability**).

Connecting accounts to planning instruments

¶1 Sub-national ocean accounts can inform several categories of local planning instruments:

¶2 **Marine spatial plans**: Sub-national extent accounts provide the baseline mapping of ecosystem distribution that underpins spatial zoning. Condition accounts identify areas under stress that may warrant protective zoning. Economic activity accounts reveal the spatial distribution of competing uses. Combined presentations (see **TG-3.8 Combined Presentations**) integrate these data into the analytical framework required by marine spatial planning processes (see **TG-1.2 Marine Spatial Planning**).

¶3 **Protected area management plans**: Marine park management plans typically require monitoring data on ecosystem condition, visitation levels, and compliance with regulations. Sub-national accounts provide a structured framework for organising this monitoring data, tracking trends over time, and linking ecosystem condition to management actions. The governance accounts described in **TG-3.7 Governance Accounts** complement ecological and economic accounts by documenting management inputs and processes.

¶4 **Coastal development plans**: Municipal and provincial governments planning coastal development require information on the trade-offs between development and ecosystem services. Sub-national accounts quantify these trade-offs by showing how ecosystem extent and condition changes affect the flow of ecosystem services (coastal protection, fish provisioning, recreation) and the economic and social consequences for local communities.

¶5 **Disaster risk management**: Coastal communities face risks from storms, flooding, and sea-level rise. Sub-national accounts documenting the extent and condition of protective ecosystems (mangroves, coral reefs, salt marshes), the economic assets at risk, and the population exposure support disaster risk assessment and adaptation planning (see **TG-2.9 Disaster Risk Indicators**).

Aggregation and national consistency

¶1 A fundamental principle of sub-national accounting is that sub-national accounts should aggregate to national totals. This principle ensures that sub-national information is consistent with national reporting and that national accounts can be disaggregated to reveal sub-national patterns. The SEEA EA states that the choice of geographical area and entities should support the potential to compare results over time and in different locations [2].

¶2 In practice, exact aggregation is achievable for extent accounts (the sum of ecosystem extent across all sub-national areas equals the national extent) and for economic-account levels (GVA, employment, output) compiled using pure top-down allocation, where by construction sub-national values sum to national totals. In hybrid procedures (Section 3.2) that combine top-down allocation

DRAFT

with bottom-up evidence or productivity-adjusted keys, additivity at the level is preserved instead through the documented residual-reallocation step rather than by construction. Derived ratios (ocean economy share of regional GDP, labour productivity by ocean industry, and similar intensity measures generated at Step 5 of the §3.2 procedure) are not additive across sub-national areas: a national ratio cannot be recovered by summing or simply averaging sub-national ratios and must be computed from the underlying levels. Condition accounts likewise do not satisfy additivity: the national condition index cannot be computed by simple summation of sub-national values. The preferred aggregation method for both condition indices and derived economy ratios is an area-weighted (or activity-weighted) mean, where each sub-national value is weighted by the relevant denominator (ecosystem area for condition indices, and GDP, employment, or output for economy ratios).

¶3 **Worked aggregation example**

¶4 Suppose two sub-national areas compile coral reef condition indices independently:

- ¶5 **Area A:** index = 0.65, reef area = 80 km²
- ¶6 **Area B:** index = 0.50, reef area = 40 km²

¶7 The national area-weighted aggregate:

¶8 (0.65 × 80 + 0.50 × 40) / (80 + 40) = (52 + 20) / 120 = **0.60**

¶9 Compilers should document this formula and note that condition indices are not additive: discrepancies between this aggregated figure and an independently compiled national condition account should be recorded and investigated.

3.6 Dashboard Design for Local Decision-Makers

¶1 Sub-national ocean accounts generate data that must be communicated effectively to local decision-makers—provincial governors, municipal mayors, marine park managers, coastal zone management authorities. These users typically require concise, visually accessible summaries rather than detailed accounting tables, organised around the management questions relevant to their jurisdiction.

¶2 The illustrative dashboard in Table 3.11.7 is compiled for the same unified entity (the **Province X Coastal Zone**) introduced in §3.3, and its indicator values are derived from the upstream Tables 3.11.5 (extent) and 3.11.6 (condition). The dashboard "Account Source" column traces each cell back to its source account and table row. Trend cells use indicative three-year extrapolations of the same monitoring series. Where an indicator cannot be derived from the upstream tables (e.g., catch / sustainable yield, which requires a stock-assessment account), the cell is marked "n/a — not illustrated" and a footnote explains the missing upstream account.

Principles of dashboard design

¶1 Effective sub-national ocean account dashboards follow the design principles set out in **TG-3.8 Combined Presentations** Section 3.5 (management-question orientation, trend emphasis, peer benchmarking). Two additional considerations are distinctive to sub-national use and warrant emphasis here:

- ¶2 **Spatial visualisation**: Present information as maps wherever possible. Sub-national accounts are inherently spatial, and a single map often communicates condition or pressure patterns more effectively than tabulated indicators.
- ¶3 **Sub-national peer benchmarking**: Where accounts are compiled for multiple sub-national areas, include cross-jurisdictional comparison alongside national benchmarks so that local decision-makers can identify peer regions for best-practice learning.

Illustrative dashboard structure

¶1 The following table illustrates a dashboard structure for the Province X Coastal Zone, drawing indicators from the upstream extent and condition accounts (Tables 3.11.5–3.11.6) and a small set of

economic and social indicators introduced at dashboard stage. The benchmark columns are split into value (a comparable national figure or target) and trend (the national rate of change), using explicit codes where national benchmarks are unavailable: "n/c" = not compiled at national level, and "n/a" = indicator does not apply at national scale.

¶2 *Table 3.11.7: Illustrative sub-national ocean accounts dashboard (Province X Coastal Zone)*

Domain	Indicator	Value	Trend (indicative, 3-year) [21]	Benchmark Value (National)	Benchmark Trend (National)	Account Source
Ecosystem extent	Total coastal/marine ecosystem area (km²)	946	Declining (-0.1%/yr)	n/c	n/c	Extent account (TG-3.1); Table 3.11.5 closing accounting-area total (946.4 km², rounded)
Ecosystem extent	Mangrove area (km²)	85.8	Increasing (+0.7%/yr)	n/c	National total declining	Extent account (TG-3.1); Table 3.11.5 mangrove closing extent; trend = +0.6 / 85.2 ≈ +0.70%/yr
Ecosystem condition	Coral reef condition index (0–1)	0.58	Declining (-0.05/yr)	0.62	-0.02/yr	Condition account (TG-3.1); Table 3.11.6 live coral cover index 2025; Δ Index = -0.05
Ecosystem condition	Water quality index (0–1, DIN-derived)	0.73	Declining (-0.06/yr)	0.78	-0.02/yr	Condition account (TG-3.1); biophysical indicator catalogue (TG-2.1); Table 3.11.6 DIN-derived index 2025; Δ Index = -0.06

DRAFT

Domain	Indicator	Value	Trend (indicative, 3-year) [21]	Benchmark Value (National)	Benchmark Trend (National)	Account Source
Ecosystem services	Fish provisioning (tonnes/yr)	n/a — not illustrated [22]	n/a	n/a	n/a	Flow account (TG-3.2); upstream physical-flow account not compiled in this worked example
Ecosystem services	Coastal protection (km of coastline)	n/a — not illustrated [22]	n/a	n/a	n/a	Flow account (TG-3.2); upstream physical-flow account not compiled in this worked example
Ecosystem services	Blue carbon sequestration (tCO2e/yr, use = Rest of World) [23]	n/a — not illustrated [22]	n/a	n/a	n/a	Flow account (TG-3.2); upstream physical-flow account not compiled in this worked example; Rest of World convention illustrated in §3.1
Ocean economy	Ocean economy GVA (million USD)	n/a — not illustrated [24]	n/a	n/c	+2.8%/yr	Economic account (TG-3.3); upstream regionalised SUT not compiled in this worked example
Ocean economy	Ocean economy employment	n/a — not illustrated [24]	n/a	n/c	+1.2%/yr	Economic account (TG-3.3); upstream regionalised SUT not compiled in this worked example

DRAFT

Domain	Indicator	Value	Trend (indicative, 3-year) [21]	Benchmark Value (National)	Benchmark Trend (National)	Account Source
Sustainability	Fish catch / sustainable yield (%)	n/a — not illustrated [25]	n/a	n/a	n/a	Asset account (TG-3.1, TG-6.7); stock assessment not compiled in this worked example
Governance	MPA coverage (% of zone)	n/a — not illustrated [26]	n/a	n/a	n/a	Governance account (TG-3.7); upstream governance account not compiled in this worked example
Social	Coastal poverty rate (%)	n/a — not illustrated [26]	n/a	n/a	n/a	Social account (TG-3.5); upstream social account not compiled in this worked example

DRAFT

From dashboard to action

¶1 Dashboards are communication tools, not ends in themselves. Their value depends on the extent to which they inform management decisions. Compilers should work with local decision-makers to identify the specific decisions that dashboard indicators will inform, establish indicator thresholds or targets that trigger management responses, and create feedback loops between management actions and subsequent account updates that demonstrate whether interventions are achieving their intended effects.

¶2 For example, the worked-example dashboard above (populated only where upstream accounts have been compiled) indicates that the Province X Coastal Zone's coral reef and water-quality condition indices have both declined over the 2024–2025 period (Δ -0.05 and -0.06 respectively, from Table 3.11.6), whilst mangrove extent has increased (+0.6 km² from Table 3.11.5) under an active restoration programme. A policy response might extend the mangrove restoration approach to seagrass and coral reef ecosystems and invest in water quality improvement to address the declining condition index. Subsequent accounting periods would reveal whether these interventions are effective. This would create an adaptive management cycle informed by sub-national ocean accounts. In an operational compilation, the remaining dashboard rows (ecosystem services, ocean economy, governance, social) would be populated from the corresponding upstream accounts. The "n/a — not illustrated" entries flag scope decisions that compilers should make explicit when planning their own dashboards.

¶3 The country case studies in **TG-5.5 Indonesia** and **TG-5.1 Australia** provide examples of sub-national ocean accounting in practice. They demonstrate how accounts compiled for specific regions or sites have been used to inform local management decisions.

Implementation Considerations

¶1 For minimum institutional capacity, data infrastructure, and human skills requirements for compiling these accounts, see TG-0.8 Implementation Readiness Assessment.

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

5. References

1. ¶1 The edge mapping reproduced in this box is anchored to TG-0.1 Figure 0.1.2 as of TG-0.1 v0.6.0. Future revisions of TG-0.1 may renumber edges or revise the framework diagram; compilers should verify the current edge identifiers against the latest TG-0.1 before publishing sub-national accounts that rely on this mapping.
2. ¶2 SEEA EA (2021), paras. 13.9–13.10. "For any given thematic accounting exercise, there is no a priori restriction on the geographical area, type of entity or classification that must be applied." and "Accounting principles are themselves equally applicable across different spatial scales and entities and are unaffected by the choice of classification. These choices should therefore be made with a focus on the use of the accounts, including the potential to compare results over time and in different locations."
3. ¶3 European Commission (2021), *Integrated system of Natural Capital and ecosystem services Accounting in the EU (INCA)*. Statistical Report, Eurostat. The INCA programme compiled ecosystem extent, condition, and ecosystem service accounts at 100 m grid resolution across the EU territory, demonstrating bottom-up spatial accounting that can be aggregated to any administrative boundary.
4. ¶4 SEEA EA (2021), paras. 3.12–3.18 (EAA and BSU definitions). The ecosystem accounting area (EAA) is "the geographical area for which an ecosystem account is compiled" and the basic spatial unit (BSU) is "the smallest unit of land or water for which information is collected and which can be attributed to a specific ecosystem type."
5. ¶5 Keith, D.A., et al. (2022), "A function-based typology for Earth's ecosystems", *Nature*, 610, 513–518. The IUCN Global Ecosystem Typology provides a hierarchical classification of the world's ecosystems into realms, biomes, ecosystem functional groups, and biogeographic ecotypes.
6. ¶6 SEEA EA (2021), paras. 3.23–3.25 (hybrid boundary documentation). Ecosystem accounting areas may be defined to suit particular analytical purposes (including hybrid combinations of administrative and ecological criteria) provided the boundaries are clearly documented and consistently applied across accounting periods.
7. ¶7 SEEA EA (2021), paras. 3.19–3.22 (BSU resolution and aggregation). BSUs are designed to support derivation of extent, condition, and ecosystem service flow accounts at the relevant spatial scale, and to support consistent aggregation to any administrative or ecological boundary of interest.
8. ¶8 TG-0.8 (Implementation Readiness Assessment) §3.1.2 uses a four-level maturity scale (Level 1 to Level 4). The three Implementation Levels defined in this §3.1 aggregate TG-0.8 Levels 3 and 4 into a single fine-resolution category, so §3.1 Implementation Level 3 corresponds to TG-0.8 Level 3 or Level 4 readiness. Compilers consulting TG-0.8 directly should map their TG-0.8 score to the §3.1 Implementation Level using this correspondence.
9. ¶9 SNA 2025 paras. 4.10–4.14 (residence principle). The residence principle allocates economic activity to the institutional unit's centre of economic interest; for sub-national accounts, this is typically the province or region where the enterprise is registered.
0. ¶10 SEEA EA (2021), Chapter 7. Ecosystem service supply is allocated to the ecosystem type providing the service; use is allocated to the economic or household unit benefiting. For global-public-good services, the Rest of World is the use-side beneficiary.
1. ¶11 Eurostat (2013), *European System of Accounts (ESA 2010)*, Chapter 13 on regional accounts. ESA 2010 Chapter 13 sets out the conceptual rule that regional accounts should be consistent with national accounts and compiled using methods that ensure additivity across regions. The detailed balancing procedures referenced here (proportional residual reallocation, RAS) are documented in Eurostat (2013) *Manual on Regional Accounts Methods* (see [12]).
2. ¶12 Eurostat (2013), *Manual on Regional Accounts Methods*. Provides the operational regional-accounts balancing procedures (RAS, proportional residual reallocation) and the product-by-region SUT extension referenced in §3.2. Compilers seeking a full product-dimension regional SUT should consult this manual rather than ESA 2010 Chapter 13, which is the conceptual framework only.
3. ¶13 SNA 2025, Chapter 25 (exhaustiveness). The SNA 2025 requires that national accounts capture all productive activity regardless of whether it is recorded in administrative data or official surveys; sub-national disaggregation should preserve this exhaustiveness property.
4. ¶14 SEEA EA (2021), Chapter 4. "Ecosystem extent accounts record the total area of each ecosystem type within an ecosystem accounting area. They are compiled in terms of area (e.g. hectares) and record opening and closing stocks and relevant additions and reductions in ecosystem extent for each ecosystem type."

DRAFT

5. ¶15 Continental shelf waters extent is recorded at 650 km² in both opening and closing stock. Em-dashes (—) in the change columns indicate that no change-detection entries were generated for the pelagic/shelf water column in this accounting period, as extent-change detection requires bathymetric or oceanographic habitat-mapping data not yet compiled for this province. The two Total rows make the resulting convention explicit: the "Total (mapped ecosystems, excl. shelf)" row sums only the rows with measured change data; the "Total accounting area (incl. shelf)" row preserves the full accounting-area extent under a constant-shelf working assumption. Readers should treat the Net Change figure as conditional on this assumption. See **TG-6.5 Pelagic and Open Ocean Accounts** for methods.
6. ¶16 SEEA EA (2021), Chapter 5. "Ecosystem condition accounts record the condition of ecosystem assets in an ecosystem accounting area. They are compiled using a set of indicators, referred to as condition indicators, organized into groups (condition characteristics)." The six condition characteristic groups are: physical state, chemical state, compositional state, structural state, functional state, and landscape and seascape characteristics.
7. ¶17 SEEA EA (2021), paras. 5.60–5.76 (rescaling of condition variables to indicators). The standard rescaling formula is: indicator = (observed − lower reference) / (upper reference − lower reference), bounded to [0, 1]. For negative-direction variables, the formula is applied symmetrically so that higher indicator values always represent better condition.
8. ¶18 Fish species richness in Table 3.11.6 is scoped to coral reef habitat (reef fish assemblage surveys conducted within Marine Park Y reef sites), rather than treated as a pan-ecosystem "all marine" indicator. SEEA EA Chapter 5 organises condition indicators by ecosystem type, and a pan-ecosystem indicator cannot be aggregated coherently with reef-, seagrass-, or mangrove-specific indicators using the area-weighted-mean rule in the interpretation paragraph. Where compilers have data on fish assemblages in additional ecosystem types (e.g., seagrass-associated fish), those should be reported as separate ecosystem-type-scoped indicators.
9. ¶19 DIN condition index rescaled using negative-direction formula: (20 − 9.1) / (20 − 5) = 10.9 / 15 = 0.73 (2025); (20 − 8.2) / (20 − 5) = 11.8 / 15 = 0.79 (2024). Upper reference VH = 5 ug/L (reference condition); lower reference VL = 20 ug/L (degraded state). Δ Index = 0.73 − 0.79 = −0.06, encoding worsening condition over the period.
0. ¶20 SEEA EA (2021), para. 13.90. "Much of the information required to compile ocean accounts is common to other communities of practice including those for marine spatial planning, disaster risk and climate change. One objective of the ocean accounting community of practice is to ensure that these common data are standardized and shared."
1. ¶21 Trend column values in Table 3.11.7 are indicative three-year extrapolations of the 2024–2025 paired observations in Table 3.11.6 (or the 2024–2025 paired extents implied by the closing stock and Net Change column of Table 3.11.5). Operational dashboards should compile trends from at least three accounting periods of the relevant underlying account rather than extrapolating from a single Δ.
2. ¶22 Ecosystem service flow indicators (fish provisioning, coastal protection, blue carbon sequestration) are marked "n/a — not illustrated" because the worked example in this Circular does not compile an upstream physical or monetary ecosystem service flow account; only extent (Table 3.11.5) and condition (Table 3.11.6) accounts are illustrated. In operational compilation, these dashboard cells would be populated from a TG-3.2 ecosystem service flow account compiled for the same Province X Coastal Zone entity. The Rest of World convention for blue carbon (footnote [23]) remains the recommended treatment for the use side of that account when compiled.
3. ¶23 Blue carbon sequestration would, if compiled, illustrate the §3.1 Rest of World convention for global-public-good ecosystem services: physical supply recorded in the Province X Coastal Zone (where mangrove and seagrass ecosystems sequester carbon), but use allocated to the Rest of World column in the sub-national use table because the beneficiary is the global community. This treatment mirrors the SEEA EA Chapter 7 handling of carbon services. The indicator is marked "n/a — not illustrated" in Table 3.11.7 (see [22]) because the upstream flow account is not compiled in this worked example.
4. ¶24 Ocean economy GVA and employment indicators are marked "n/a — not illustrated" because the worked example does not compile an upstream regionalised ocean economy supply-use table for the Province X Coastal Zone; the §3.2 procedure describes the methodology but is not exercised on a numerical example in this Circular.
5. ¶25 Fish catch / sustainable yield cannot be illustrated in this worked example because the upstream Tables 3.11.5 and 3.11.6 do not include a fish stock or maximum sustainable yield estimate for the Province X Coastal Zone. Compilers producing this indicator should derive it from an asset account or stock assessment (see **TG-6.7 Fisheries Stock Assessment**) and cite the source MSY estimate.
6. ¶26 Governance (MPA coverage) and social (coastal poverty rate) indicators are marked "n/a — not illustrated" because the worked example does not compile upstream governance (TG-3.7) or social (TG-3.5) accounts for the Province X Coastal Zone.

Quality Assurance and Quality Control of Ocean Asset Accounts

Sets out the checks, records and independent review that show an ocean asset account — physical or monetary, individual resource or ecosystem — is complete, balanced and fit to publish.

Version 0.3.0 **Status** Draft **Stability** Applied

Last updated September 2026 **Responsible officer** Dr Jordan Gacutan

Drafting AI-assisted drafting from GOAP Secretariat source materials; source list to be published at the close of consultation.

DRAFT

OUTCOME

After working through this Circular, you will be able to show that an ocean asset account is complete, balanced and fit to publish, and to hand a reviewer the evidence that confirms it. You will be able to:

- write a quality assurance and quality control (QA/QC) plan for an asset account: the generic core every account needs, and the asset-account part;
- run and log the general checks and the asset-type acceptance checks, physical and monetary;
- reconcile the account with the supply and use tables, the production account, government finance statistics, the greenhouse gas inventory and the national balance sheet;
- give every cell a grade and a status, and carry them into aggregates;
- quantify the uncertainty in asset values and report it as a range;
- pass independent review with a complete evidence pack.

The Circular sets no accounting rule of its own. Every rule it tests is owned by the circular named beside the check, most often TG-3.1 Asset Accounts; what this Circular adds is the procedure, the tolerance and the record.

CONTENTS

1. Outcome 3
2. Requirements 3
3. Guidance Material 4
3.1 Concepts, Scope and Layers 4
3.2 QA/QC Plan and Data-Quality Objectives 5
3.3 Methodological Issues 7
3.4 General QC Checks 8
3.5 Asset-Type Acceptance Checks 11
3.6 Reconciliation and Verification 13
3.7 Quality Flags for Asset Cells 15
3.8 Worked Example: A Coastal Asset Account with Seeded Errors 16
3.9 Uncertainty Assessment 19
3.10 Review, Documentation and Release 19
3.11 Limitations 20
4. Acknowledgements 20
5. References 21

ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Quality Assurance and Quality Control of Ocean Asset Accounts (2026) (GOAP Technical Guidance on Ocean Accounting, TG-3.16, v0.3.0). GOAP Secretariat. https://guidance.oceanaccounts.org/circulars/section-3/3-16-asset-accounts-qaqc/

© 2026 Global Ocean Accounts Partnership. Licensed under CC BY-NC 4.0.

DRAFT

1. Outcome

¶1 After working through this Circular, you will be able to show that an ocean asset account is complete, balanced and fit to publish, and to hand a reviewer the evidence that confirms it. You will be able to:

- ¶2 write a quality assurance and quality control (QA/QC) plan for an asset account: the generic core every account needs, and the asset-account part;
- ¶3 run and log the general checks and the asset-type acceptance checks, physical and monetary;
- ¶4 reconcile the account with the supply and use tables, the production account, government finance statistics, the greenhouse gas inventory and the national balance sheet;
- ¶5 give every cell a grade and a status, and carry them into aggregates;
- ¶6 quantify the uncertainty in asset values and report it as a range;
- ¶7 pass independent review with a complete evidence pack.

¶8 The Circular sets no accounting rule of its own. Every rule it tests is owned by the circular named beside the check, most often **TG-3.1 Asset Accounts**; what this Circular adds is the procedure, the tolerance and the record.

2. Requirements

¶1 **Essential prerequisites:**

- ¶2 **TG-0.1 General Introduction to Ocean Accounts**: conceptual framework and the three-domain structure
- ¶3 **TG-0.7 Quality Assurance Principles**: quality dimensions, uncertainty categories, documentation categories and quality flags
- ¶4 **TG-3.1 Asset Accounts**: the asset account tables, identities and compilation procedure that the checks test

¶5 **Helpful background:**

- ¶6 **TG-2.1 Aggregate Biophysical Indicators of Environmental State**: condition rescaling and aggregation
- ¶7 **TG-1.9 Safe Usage of Monetary Valuation** and **TG-2.4 Environmental (including Ecosystem) Goods and Services** Section 3.10: valuation choices and service-level methods
- ¶8 **TG-4.1 Remote Sensing and Geospatial Data** and **TG-2.12 Spatial Data Frameworks**: extent accuracy and the spatial rules
- ¶9 **TG-4.8 Physical Condition Measurement** and **TG-4.9 Biological Condition Measurement**: condition variables
- ¶10 **TG-6.7 Fisheries Accounting: Integrating Stock Assessment**: the stock assessment behind the fish account
- ¶11 **TG-0.8 Implementation Readiness Assessment**: the institutional checklist (Section 3.5.2)

DRAFT

¶12 **Framework Position**

¶13 This Circular addresses the stock side of the Ocean Accounts Framework, at the same edges as TG-3.1: the asset accounts that record SNA produced assets (SG1) and environmental assets (SG3). In the Ocean Accounts Framework (TG-0.1 Figure 0.1.2):

Edge	Direction	Description
E3	FG1 ↔ SG1	Economic flows interacting with SNA assets (Applied)
E9	SG3 → FG1	Environmental assets supplying ecosystem services to economy (Applied)
E11	FG3 ↔ SG3	Environmental assets supporting intermediate ecosystem services (Applied)

¶14 **Scope.** TG-3.16 owns the QC procedure, the tolerances and the evidence for the asset account tables of TG-3.1, and the reconciliations between those tables and the accounts beside them. It covers asset accounts only. The QC of the other Section 3 accounts — flows (**TG-3.2**, **TG-3.4**), economic activity (**TG-3.3**), social (**TG-3.5**) and governance (**TG-3.7**) accounts, and combined presentations (**TG-3.8**) — sits with TG-0.7 and the circular that owns each account; TG-3.16 meets them only where they reconcile with an asset cell (Section 3.6). It sets no accounting rule of its own and records no account entry, so it shares none.

3. Guidance Material

¶1 An asset account can balance and still be wrong. The identity *opening + additions − reductions = closing* holds in any account whose compiler has closed it on a residual, and a residual can absorb a dropped conversion, a double-counted loss or a unit slip without trace. The worked example in Section 3.8 carries nine seeded errors, and every column in it balances. The identity is necessary, and it is the first check; it is not sufficient, and the rest of this Circular is about what else has to be tested.

3.1 Concepts, Scope and Layers

¶1 **Interim defaults pending Secretariat decision**

¶2 Four conventions this Circular depends on are not yet settled. Until they are, it uses these defaults, and comments on them are invited: a two-field flag of grade and status (C2, Section 3.7); the uncertainty ladder of Section 3.9 at 95% (C3); exchange values only, one carbon price per account (C4, AQ-VA6), which departs from TG-6.2 Section 3.6, where the social cost of carbon is accepted for carbon retention; and the indicative tolerances of Tables 3.16.4 and 3.16.5 (C7).

¶3 The three terms below are used in the IPCC sense throughout (Table 3.16.1)[1]. They separate who performs a check from what it is compared against, and the separation is what makes a review independent.

Term	Performed by	Compares the account with
Quality control (QC)	The compilers, routinely, during compilation	Its own inputs, identities and rules
Quality assurance (QA)	People not involved in compiling it	The evidence pack, by recomputation and review
Verification	Either, using methods external to the account	Independent data: a global product, another assessment, a neighbouring account

¶4 *Table 3.16.1: Terms, after IPCC (2006) Volume 1 Chapter 6 Box 6.1.*

¶5 **Scope.** The checks apply to the asset accounts of TG-3.1, physical and monetary, as the Framework Position sets out: SEEA CF individual environmental assets (coastal aquifers only for water), SEEA EA extent, condition and monetary ecosystem assets, and produced assets only where they touch environmental assets.

DRAFT

¶6 **Basis.** No SEEA publication gives a quality assessment framework of its own. The SEEA EA sets out the quality dimensions and the uncertainty categories (paras 2.86–2.95), points compilers to the IMF Data Quality Assessment Framework (para 2.89), and lists the articulation of data quality assessment frameworks in its research agenda as work still to do [2]. The SEEA Central Framework treats quality as data confrontation: putting estimates into an accounting framework exposes their inconsistencies (paras 1.54, 6.7, 6.86), and revisions are "standard practice" (para 6.68) [3]. This Circular therefore draws the procedure from general frameworks the SEEA points to: UN-NQAF requirement 15.1, that source data, intermediate results and outputs are regularly assessed and validated [4]; IMF DQAF element 3.4, validation of intermediate data and outputs [5]; and GSBPM v5.2 sub-processes 5.3 (review and validate) and 6.2 (validate outputs) [6].

¶7 **Layers.** The Circular follows the pattern the IPCC inventory guidelines use for the same problem: general procedures are written once, and category procedures sit with the category [1]. TG-0.7 holds the principles; for this consultation TG-3.16 also carries the generic QC core (Section 3.2). TG-3.16 holds QC for the asset-account category, shared by TG-3.1 and the Section 6 circulars that populate asset accounts. TG-3.1 and each Section 6 circular keep their rules, and list in their own quality subsection only the checks distinctive to them. Figure 3.16.1 places each kind of check in the statistical production process.

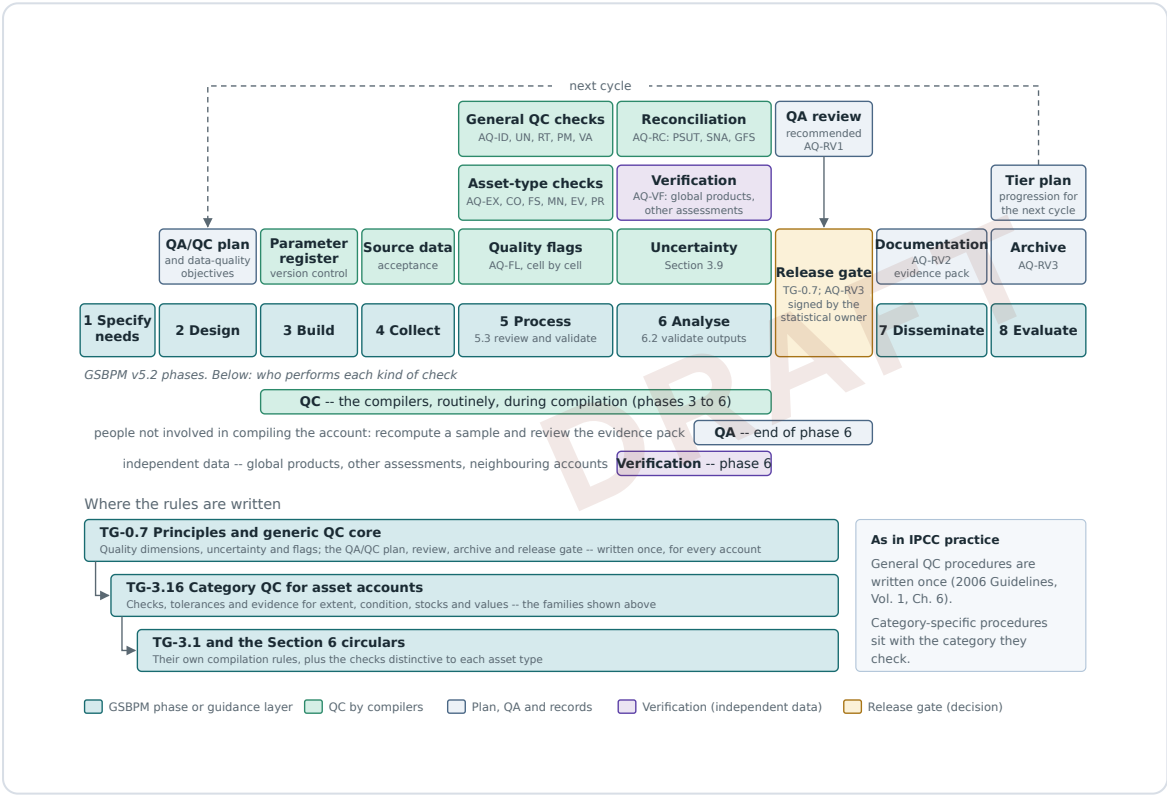


Figure 3.16.1 QC runs inside compilation; QA and verification sit at its end, and the release gate closes it. General rules are written once in TG-0.7, asset-account checks in TG-3.16, and distinctive checks in the owning circulars, as IPCC practice does. Check families are shown, not individual checks.

Source: IPCC (2006) 2006 IPCC Guidelines, Vol. 1, Ch. 6, Box 6.1 and Sections 6.5–6.10; UNECE GSBPM v5.2, sub-processes 5.3 and 6.2; TG-3.16.

Note: Check identifiers carry the prefix AQ- (asset QC); a family such as AQ-ID groups the numbered checks of Tables 3.16.4 and 3.16.5. The tiers of Section 3.2 set which checks are the minimum.

¶8 Check identifiers carry the prefix **AQ-** (asset QC), so a QC log can cite *AQ-ID3* without ambiguity against another circular's numbering.

3.2 QA/QC Plan and Data-Quality Objectives

¶1 **Generic QC core, carried here for consultation**

¶2 The plan, the roles, the records, QC intensity (this section), independent review, the archive, the release gate and the generic evidence pack (Section 3.10), and the uncertainty ladder (Section 3.9) apply to every ocean account, not only to asset accounts. They are set out here so that this Circular can be read and used on its own during the consultation. After the consultation closes they move to **TG-0.7**, and this Circular will keep only the asset-account application. Comments on where this core should sit are welcome.

¶3 A QA/QC plan is written before compilation starts and names the checks, who runs them and when, the independent reviewer, the release gate, the tolerance register and the data-quality objectives[1]. It is the document a reviewer reads first, and it is what TG-0.8's checklist item 8 asks an institution to have adopted. For an asset account the plan also says what each data-quality objective means for assets, which checks each tier runs, and which parameters the parameter register holds (Section 3.3).

¶4 **Roles.** Six roles carry the plan. One person may hold several in a small office, with one exception: the independent reviewer may not also be a compiler.

- ¶5 **Compiler**: runs every QC check in Sections 3.4 to 3.7 and keeps the QC log.
- ¶6 **Data manager**: keeps the source register, metadata, archive and version control.
- ¶7 **QA/QC coordinator**: owns the plan, schedules the reviews and keeps the issue register.
- ¶8 **Independent reviewer**: not involved in compilation (AQ-RV1).
- ¶9 **Statistical owner** (usually the national statistical office): signs off official figures, confidentiality and SDG custodian alignment.
- ¶10 **Community authority**: approves publication of traditional knowledge and community data (**TG-3.6**).

¶11 **Records.** Three records are kept from the first day: the **QC log** (check, cell, result, action, initials, date); the **issue register** (open or closed, and whether each issue blocks release); and the **parameter register**, the single place every parameter is set (Section 3.3).

¶12 **QC intensity.** QC effort scales with tier and with materiality. A representative sample of derived cells may be checked in any one cycle, provided every part of the account is covered over successive cycles[1]. Headline figures and every figure quoted in narrative text are recomputed in every cycle, whatever the tier (AQ-UN4).

DRAFT

¶13 **Data-quality objectives.** The plan sets the seven data-quality objectives of the IPCC guidelines[1]. For an asset account each means the following (Table 3.16.2), and each needs a national value in the plan.

Objective	What it means for an asset account
Completeness	Every asset type in the accounting area is compiled, or shown as ".." with a reason
Consistency	Every identity closes; the series uses one method or its breaks are logged
Comparability	IUCN GET at level 3 or finer; fixed classification versions; one equal-area CRS
Accuracy	Extent accuracy thresholds met; stock coefficient of variation stated
Timeliness	Release lag after the reference period stated and met
Transparency	Evidence pack complete, including the asset items of Table 3.16.8
Improvement	A tier-progression plan for the next cycle

¶14 *Table 3.16.2: Data-quality objectives for an asset account, after IPCC (2006) Volume 1 Section 6.5.*

¶15 **Tiers.** Tier 1 is the minimum viable approach and higher tiers add rigour, as in TG-0.7 Section 3.8. The tiers here are proposed for consultation:

- ¶16 **Tier 1 (minimum).** AQ-ID1 to AQ-ID4, AQ-ID6, AQ-UN1, AQ-UN4, AQ-PM3, AQ-VA6, AQ-FL1 and one verification check, plus the Table 3.16.5 acceptance checks for every asset type compiled.
- ¶17 **Tier 2.** Every check in Tables 3.16.4 to 3.16.6, with at least 10% of derived cells recomputed.
- ¶18 **Tier 3.** Tier 2, with Monte Carlo uncertainty for every monetary asset and a subject-specialist reviewer for each of the stock, extent and valuation parts.

¶19 The worked example measures what the minimum misses: Tier 1 catches six of the nine seeded errors, and the three it does not catch (net recorded as gross, a condition index applied twice, and a loss valued twice) are the case for Tier 2.

¶20 **QC log template.** Tables 3.16.4 to 3.16.6, with columns added for the result, the action, initials and date, are the template for the QC log. For condition cells the log also records the expected range, its source in the reference-value register, and the range verdict under AQ-CO7 (inside the usual range; unusual but within the plausibility range; or outside it and investigated).

3.3 Methodological Issues

¶1 **Parameter register.** Every parameter that scales a result is set once, in one register, with its source, vintage and owner. For an asset account it holds: the discount rate and horizon, the carbon price and its basis, unit prices and rents, live-weight conversion factors, the carbon-to-CO_2 factor of 44/12, reference levels, the minimum mapping unit and the CRS pair. A value typed into a formula is a finding in itself, because it cannot be changed consistently.

¶2 **Source-data acceptance.** Data from monitoring, research and administrative sources often concentrate on edge or problem cases, and need review against the measurement concepts and scope of the account before use (SEEA EA paras 2.87–2.88)[2]. That review belongs to the Section 4 circular that delivers the variable, with its definition, source, unit, coverage, reference value, uncertainty and quality tier (**TG-0.4** Section 4.5). The account's test is only that each value arrives with those attributes, a flag and its location in the primary source (a table cell or a quotation); a value without them goes back to its Section 4 owner. The location matters because values copied through secondary syntheses drift: an index is re-labelled as a stock, a biomass figure as carbon, or a value measured in another country is attached to a local place name. A value that cannot be traced to its primary source is not entered.

¶3 **Double counting.** Four pairs cause most of it, and each has a check: fish-stock value and provisioning flow (AQ-ID6; **TG-6.7** Section 3.5), produced and ecosystem protection (AQ-PR1), rent and government receipts (AQ-RC4), and nursery services (AQ-VA7).

¶4 **Time series and revisions.** Every revision is documented (SEEA EA para 10.40)[7], breaks are back-cast where feasible (TG-0.7 Section 3.2.4), and the asset account revises when and as the national accounts do, so that the two revisions policies stay aligned (SEEA CF para 6.70)[3]. Table 3.16.3 sets the two cases. A back-revision that moves a published indicator by more than 5% is republished, the threshold **TG-4.5** Section 3.5.4 sets.

Cause of the revision	Individual environmental asset	Ecosystem extent and condition	Monetary ecosystem asset
New data, same asset, same method	Reappraisal, current period	Reappraisal, shown as an identified line (SEEA EA 4.17)[8]	Reappraisal (SEEA EA 10.38)[9]
New method, source, classification or reference level	Benchmark revision at rebasing: restate, back-cast, log the break	Benchmark revision at rebasing: restate, back-cast, log the break	Benchmark revision at rebasing: restate, back-cast, log the break

DRAFT

¶5 *Table 3.16.3: Treatment of revisions, aligned with national accounts benchmark revision and rebasing.*

3.4 General QC Checks

¶1 ⚠ **Known issues in the TG-3.1 worked example**

¶2 Several checks below name TG-3.1 as the owner of their rule. The TG-3.1 worked example does not yet pass all of them, and the corrections are scheduled for the revision after this consultation: a reclassification is not shown in Table 5 (AQ-ID4); storm damage is booked as catastrophic loss within the regrowth horizon (AQ-RT1); restoration is valued as enhancement before the survival check (AQ-RT4); the seagrass linear-shortcut test is applied below its 70% condition (AQ-VA3); and depletion is equated with extraction (AQ-PM3). Read the TG-3.1 rules, not its example, until then.

¶3 The general checks apply to every asset account, whichever asset type it holds (Table 3.16.4). They are written in the style of the IPCC general inventory QC table[1]: each is a test with a pass condition, and the rule it tests belongs to the circular in the right-hand column. **Tolerances belong in the national QA/QC plan**, and this Circular strongly recommends that they be set there, taking account of regional conditions: the regional products and assessments a country verifies against, the regional fisheries body's assessment practice, and regional differences in ecosystem variability and data. The tolerance column gives indicative values only, for use until the plan sets its own; *plan* marks a check with no indicative value. The evidence each check leaves is listed in the evidence pack (Table 3.16.8).

ID	Check	Indicative tolerance	Rule owner
Identities			
AQ-ID1	Opening + additions − reductions (+ revaluation) = closing, per column. A residual is shown as a reappraisal, never absorbed	Zero, to rounding	TG-3.1 Section 3.1; Table 1b
AQ-ID2	Opening = previous closing; any restatement logged	Zero, or a logged restatement	TG-3.1
AQ-ID3	Sum of opening extents = sum of closing extents = accounting area, computed in an equal-area CRS	Zero, to rounding	TG-3.1 Table 2a; TG-2.12
AQ-ID4	Net reclassification = 0, and every reduction has a destination type or a recorded change to the accounting-area boundary	Zero	TG-3.1 Table 2b
AQ-ID5	Change-matrix margins = opening and closing extent; gross conversions come from the off-diagonals, never a net figure used as gross	Zero, to rounding	TG-3.1; TG-4.1
AQ-ID6	Totals = sum of parts. Memorandum, experimental, ABNJ and produced rows, and the stand-alone SEEA CF stock value, stay out of ecosystem totals	Zero	TG-3.1; TG-6.7
Units and recomputation			
AQ-UN1	Order of magnitude: ha against km², USD against USD thousand, one price base per table; the implied unit value of every monetary entry with a physical counterpart is checked	Ratio within $10^{\pm 0.5}$	Generic check (moves to TG-0.7)
AQ-UN2	Carbon unit stated on every row; 44/12 recorded; the price unit matches the quantity unit	Exact	Generic check (moves to TG-0.7)

DRAFT

ID	Check	Indicative tolerance	Rule owner
AQ-UN3	Catch in live-weight equivalent, from one conversion-factor source per species and form	Exact	TG-3.1 Step 4
AQ-UN4	Every figure quoted in text recomputed, and a sample of derived cells (at least 10% at Tier 2)	Exact at the printed precision	Generic check (moves to TG-0.7)
Routing			
AQ-RT1	Type changed: conversion. Condition lost in a discrete event: catastrophic loss. Gradual decline: degradation. Storm damage is an extent change only beyond the regrowth horizon	Rule	TG-3.1 Section 3.5.3
AQ-RT2	Revisions kept apart from genuine change, with the revision class logged (Table 3.16.3)	Rule	TG-3.1; TG-6.7
AQ-RT3	A mineral class move is a reclassification, not a discovery	Rule	TG-3.1 Section 3.4.2
AQ-RT4	Planting enters extent only after the year-3 survival check; a condition gain is enhancement	Rule	TG-6.2
Physical to monetary			
AQ-PM1	Each monetary volume entry = its physical entry × the stated unit value; no quantity valued in two rows	Zero, to rounding	TG-3.1 Section 3.3
AQ-PM2	Opening value per unit of stock agrees with the flow valuation, or the difference is explained	Plan	TG-3.1 Section 3.4.1
AQ-PM3	Depletion traces: renewable, max(0, extraction − sustainable yield at current biomass); non-renewable, extraction; valued at the mid-period price; a constant-price memorandum line	Zero, to rounding	TG-3.1; TG-6.7
AQ-PM4	Degradation traces to the index decline in Table 3c × the present value of the affected services. No index, no entry	Zero, to rounding	TG-3.1 Sections 3.5.2–3.5.3
AQ-PM5	Value change split into volume, reappraisal and revaluation; a constant-price view published; a physical decline beside a monetary gain explained	Rule	TG-3.1 Step 5
Valuation			
AQ-VA1	One resource-rent formula; normal return on produced capital deducted once; rent not negative; an unmanaged stock carries zero core value	Zero, to rounding	TG-3.1; TG-6.7
AQ-VA2	Condition adjustment applied once, at the service-flow step; the chain audited from flow to value	Equal to the index	TG-3.1 Section 3.5.3
AQ-VA3	Linear degradation shortcut only where the decline is at most 0.20, no thresholds are documented, and one service exceeds 70% of annual flow value	0.20; 70%	TG-3.1 Section 3.5.3
AQ-VA4	Horizon and trajectory stated; a perpetuity justified; a declining condition projected or the reason it is not recorded	Stated	TG-3.1 Section 3.5.3
AQ-VA5	Discount rate and source stated; sensitivity at three or more rates	Three or more rates	TG-1.9

DRAFT

ID	Check	Indicative tolerance	Rule owner
AQ-VA6	Exchange values only, so no social cost of carbon or willingness to pay in a cell; one carbon price per account, under the TG-6.2 rule	Exchange value only	TG-1.9; TG-6.2
AQ-VA7	Ecosystem contribution only; nursery and other intermediate services excluded; no licence fees or gross revenue	Rule	TG-3.2

¶4 *Table 3.16.4: General QC checks for asset accounts. Indicative tolerances are for national plans to replace; those not taken from a rule owner are GOAP proposals.*

¶5 Two of the rules these checks test are easier to follow as diagrams. Figure 3.16.2 is the routing rule behind AQ-RT1: which row a change enters, depending on what the event did. Figure 3.16.3 is the trace behind AQ-PM3, AQ-PM4 and AQ-VA2: how each monetary depletion and degradation entry is recomputed from a physical one, and the single point at which the condition index enters.

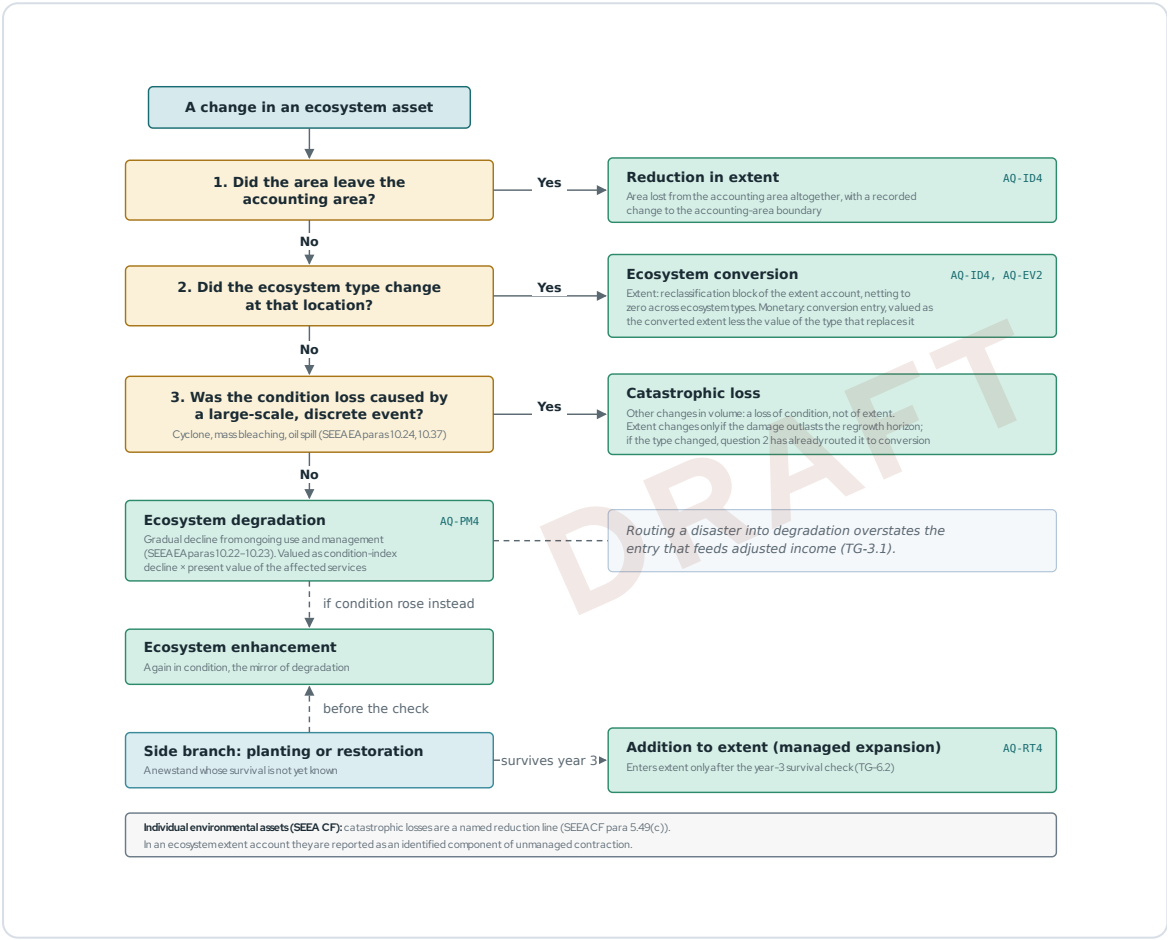


Figure 3.16.2 Where an event enters the account depends on what it did: moved the boundary, changed the type, or reduced condition suddenly or gradually. Ochre boxes are the questions, asked in order; green boxes are the account rows.

Source: TG-3.1 Sections 3.5.1 and 3.5.3; SEEA EA paras 4.15, 10.22–10.23, 10.24, 10.37.

Note: Storm damage changes extent only beyond the regrowth horizon; planting enters extent after the year-3 survival check (TG-6.2).

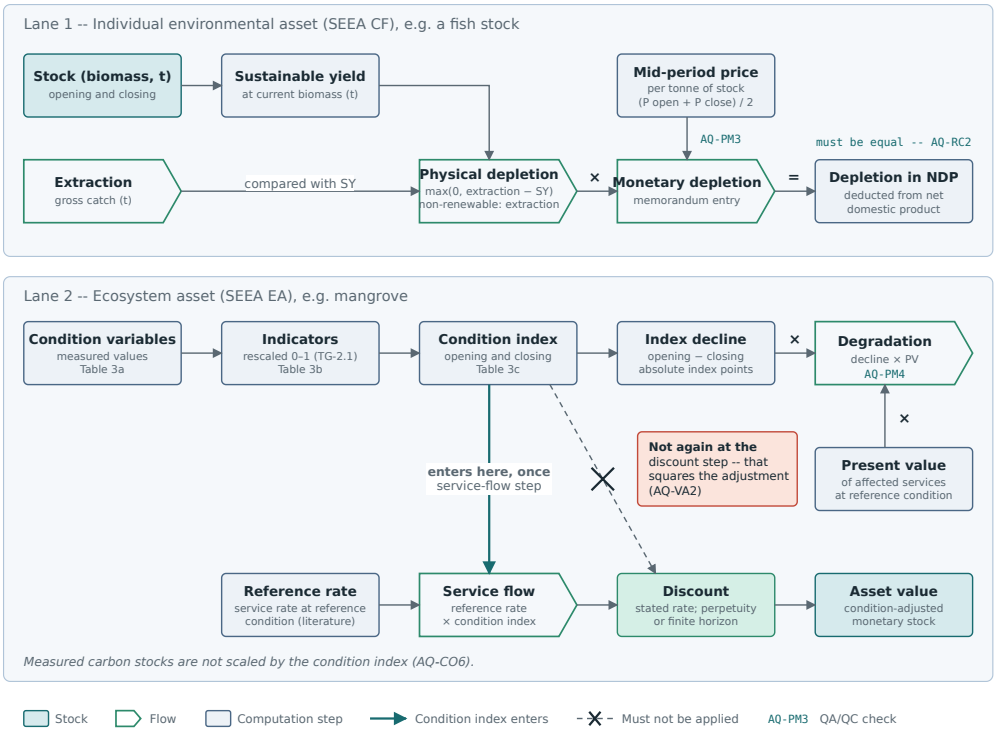


Figure 3.16.3 Every monetary depletion and degradation entry traces back to a physical entry, and the condition index enters the valuation once, at the service flow.

Source: TG-3.1 Sections 3.3 and 3.5.3; TG-2.1 Section 3.4.1.

Note: The linear degradation formula applies only within the three conditions of TG-3.1 Section 3.5.3 (AQ-VA3).

DRAFT

3.5 Asset-Type Acceptance Checks

¶1 An asset-type check is an acceptance test at the interface between the account and the method that feeds it, as TG-3.1 frames the requirements a stock assessment must meet. The account does not re-run the method. It tests whether what arrives is usable, and sends it back to the owning circular if not (Table 3.16.5).

ID	Acceptance check	Owner of the method
Aquatic resources		TG-6.7
AQ-FS1	Total biomass for opening and closing stock; SSB for B/B_{MSY} and sustainable yield; no switch of concept between periods	TG-6.7
AQ-FS2	Reported catch within the plan's tolerance of the assessment-implied catch (TG-6.7 Section 3.3, Step 6); the gap between the identity and the assessed closing stock shown as a reappraisal	TG-6.7
AQ-FS3	Gross catch includes discards by sector; IUU catch is recorded by the residence of the vessel (TG-4.10 Section 3.8.4); subsistence catch is estimated where it exceeds about 10% of harvest	TG-6.7; TG-4.10
AQ-FS4	CPUE alone does not close the account, and the metadata say so	TG-3.1
AQ-FS5	Assessment vintage recorded; a revised reference point is a reappraisal	TG-6.7
AQ-FS6	Cultivated and natural stocks kept apart	TG-3.9

ID	Acceptance check	Owner of the method
Mineral and energy resources		TG-3.10; TG-6.9
AQ-MN1	Classes A to C recorded; only Class A valued	TG-3.1 Section 3.4.2
AQ-MN2	Terminal (decommissioning) costs written off through consumption of fixed capital, so the rent is net of them; depletion kept apart from consumption of fixed capital	TG-3.10; TG-6.9
AQ-MN3	Installations (AN11), non-renewable resources (AN321) and renewable energy resources (AN322) never summed; ABNJ in satellite tables only	TG-3.10; TG-6.6
Water		TG-3.1 Section 3.4.3
AQ-WA1	Seawater outside the asset boundary; coastal aquifers only	TG-3.1
Extent		TG-4.1; TG-2.12
AQ-EX1	Probability sample of at least 50 points per class (30 for rare classes); accepted at overall accuracy of 80% and producer's and user's accuracy of 75%, otherwise "conditionally accepted" and graded C	TG-4.1 Sections 3.4.2–3.4.3
AQ-EX2	Area-adjusted estimate and its 95% confidence interval reported beside every mapped extent	TG-4.1 Section 3.4.3
AQ-EX3	Minimum mapping unit, dominance rule and equal-area CRS as TG-2.12 sets them	TG-2.12
AQ-EX4	Imagery within ±90 days of the period boundary (±45 days for high-seasonality types); an inter-layer lag over 6 months assessed, an area effect over 1% disclosed	TG-2.12
AQ-EX5	Deep seagrass recorded as a lower bound	TG-6.3
AQ-EX6	A confirmed zero recorded as 0; no data recorded as ".."	TG-0.7
Condition		TG-2.1; TG-4.8; TG-4.9
AQ-CO1	L, U, polarity and vintage fixed before data are collected, and held for the series. L and U come from the same ecosystem type and setting as the reporting unit; a naturally low-stature or low-cover setting is not treated as a degraded state of another	TG-2.1 Section 3.4.2
AQ-CO2	Rescaling by TG-2.1 Section 3.4.1 only; indicators in [0, 1]; V/ref not used unless a lower reference of zero is justified	TG-2.1
AQ-CO3	At least one variable per ECT class	TG-3.1 Section 3.5.2
AQ-CO4	Aggregation rule and weights stated; geometric-mean and one-out-all-out results reported as sensitivity	TG-2.1 Section 3.6
AQ-CO5	All three condition tables published; standard errors propagated to the index	TG-3.1 Section 3.5.2
AQ-CO6	Condition never used as a multiplier on measured carbon	TG-6.2; TG-6.3

DRAFT

ID	Acceptance check	Owner of the method
AQ-CO7	Each condition variable value lies within the plausibility range for its reporting unit and setting, or is flagged and its explanation logged. The range comes from the national reference-value register, and pooled national ranges are not used where values depend on setting	TG-4.8; TG-4.9
Monetary ecosystem		TG-3.1 Section 3.5.3; TG-2.4
AQ-EV1	AQ-VA2 to AQ-VA7 applied service by service	TG-3.1
AQ-EV2	Conversion value = converted extent × its unit value, less the value of the type that replaces it	TG-3.1 Section 3.5.3
AQ-EV3	Reappraisal kept apart from revaluation	TG-3.1 Section 3.5.3
AQ-EV4	Initial monetary releases labelled experimental	TG-3.1
Produced assets		TG-6.11; TG-3.1 Section 3.6
AQ-PR1	Never summed with ecosystem assets	TG-6.11
AQ-PR2	Decommissioning memorandum included	TG-3.1 Section 3.6
AQ-PR3	No protection value recorded on the produced side	TG-6.11

¶2 *Table 3.16.5: Asset-type acceptance checks. Each tests a rule set by the circular in the right-hand column; the extent thresholds are TG-4.1's.*

¶3 **Area estimates.** Where the area-adjusted estimate of AQ-EX2 (Olofsson et al. 2014)[10] differs from the mapped area by more than the plan's tolerance, the account records the estimate and says so. This rule is proposed, for the owners of TG-4.1 and TG-2.12 to confirm.

DRAFT

3.6 Reconciliation and Verification

¶1 **Reconciliation** tests the asset account against the accounts compiled beside it. Each pair in Table 3.16.6 must agree within the plan's tolerance, or the difference is explained in the log. None of these pairs is new: each is required by the circular that owns the neighbouring account. What this Circular adds is the requirement to run all of them and record the result (Figure 3.16.4).

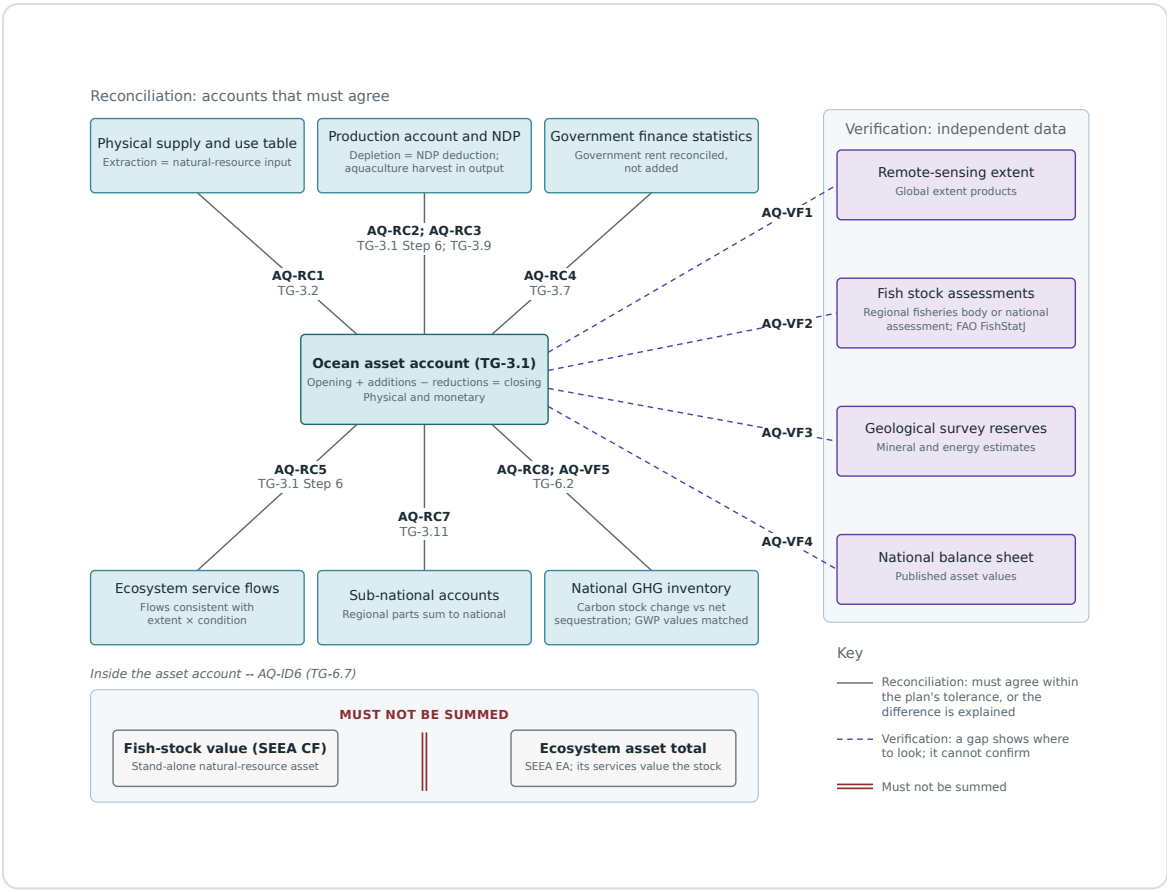


Figure 3.16.4 The asset account is reconciled with neighbouring accounts and verified against independent data; each spoke names its check and owning circular.

Source: TG-3.1 Step 6; TG-3.2; TG-3.7; TG-3.11; TG-6.2; IPCC (2006) Vol. 1, Ch. 6, Section 6.10; IMF DQAF element 3.4.

Note: Reconciliation pairs must agree within the tolerance in the QA/QC plan or be explained in the log.

DRAFT

ID	Asset-account cell	Must agree with	Owner
AQ-RC1	Extraction	Natural-resource input in the physical supply and use table	TG-3.2; TG-3.1 Step 6
AQ-RC2	Depletion	Depletion deducted in net domestic product	TG-3.1 Step 6
AQ-RC3	Aquaculture harvest	Harvest in the production account	TG-3.9
AQ-RC4	Total resource rent	Government rent receipts and government finance statistics, reconciled, not added	TG-3.7; TG-3.1
AQ-RC5	Service flows	Extent × condition capacity	TG-3.1 Step 6
AQ-RC6	Change-matrix margins	Opening and closing extent (run as AQ-ID5)	TG-3.1
AQ-RC7	Sub-national parts	National totals, with ratios rebuilt from levels	TG-3.11
AQ-RC8	Carbon stock change	Net sequestration, in sign and order of magnitude	TG-6.2; TG-6.3

¶2 *Table 3.16.6: Reconciliation matrix.*

¶3 **Verification** compares the account with data from outside it[1], [5]. It cannot confirm a figure, because the comparator has its own error, but a large gap shows where to look. The checks are:

- ¶4 **AQ-VF1.** Extent against a global product; document the cause of a gap over 15% (TG-4.1 Section 3.3.5).
- ¶5 **AQ-VF2.** Stock against the regional fisheries body's or the national assessment, and catch against FAO FishStatJ.
- ¶6 **AQ-VF3.** Mineral and energy reserves against the geological survey.
- ¶7 **AQ-VF4.** Monetary totals against the national balance sheet.
- ¶8 **AQ-VF5.** Carbon stocks and flows against the national GHG inventory, with global warming potentials matched to the inventory's.

¶9 **Trend checks.** Each cycle is compared with the previous one, following IPCC practice[1]. Implied unit prices and unit rents are compared across years, and any extent change beyond the national threshold in the plan is investigated.

3.7 Quality Flags for Asset Cells

¶1 TG-0.7 Section 3.6 defines one flag scheme. This Circular applies it to asset cells in two fields, so that a cell can say both how good it is and how it was obtained (Figure 3.16.5):

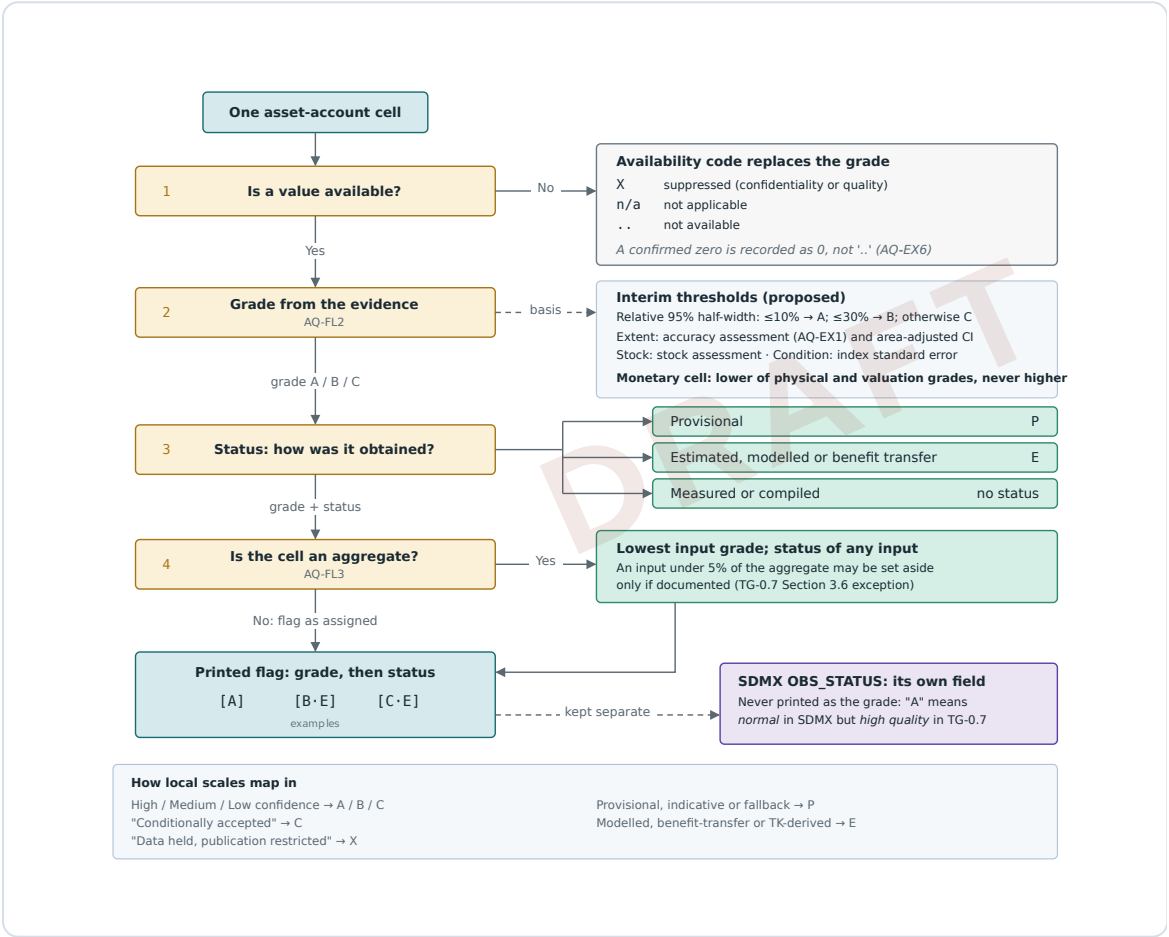


Figure 3.16.5 Each asset cell carries a grade from its evidence and a status from how it was obtained; availability codes replace the grade. Aggregates take the lowest input grade, and SDMX observation status stays in its own field.

Source: TG-0.7 Section 3.6 (flag scheme and lowest-flag rule); TG-3.16 Section 3.7 (AQ-FL1 to AQ-FL3).

Note: Grade thresholds are interim and proposed for consultation.

- ¶2 **AQ-FL1: two fields per cell.** A **grade** (A, B or C) and a **status** (P for provisional, E for estimated, or none). The availability codes X, n/a and ".." replace the grade. An SDMX observation status, where reported, goes in a third field and is never printed as the grade ("A" means *normal* in

SDMX). In the tables of Section 3.8 the flag follows the value in brackets, grade first: `[A]`, or `[C·E]` for a grade-C estimated value.

- ¶3 **AQ-FL2: what a grade rests on.** The grade basis is proposed for consultation, as follows. Extent takes its grade from AQ-EX1 and the width of the area-adjusted confidence interval. A stock takes its grade from the stock assessment, and condition from the standard error of the index. Where no standard error can be computed, which is common where condition variables come from published studies and non-probability surveys, the condition grade rests on the evidence behind each input instead: A for a full-text primary source that reports n and a labelled dispersion type; B for a full-text source without them, or a statistic the compiler computed from non-probability survey records; C for a value read from an abstract, from grey literature or digitised from a figure. A regional or global proxy takes status E. The index takes the lowest grade of its inputs under AQ-FL3. A monetary cell takes the lower of its physical grade and its valuation grade, and never a higher one. The interim thresholds, adopted as a proposal only pending decision on the flag scheme, are a relative 95% half-width of at most 10% for A and at most 30% for B, with C above that.
- ¶4 **AQ-FL3: propagation.** An aggregate takes the lowest grade of its inputs, and the status of any. A closing stock takes the lowest flag of its opening stock and its flows, and depletion takes the flag of the sustainable yield. The TG-0.7 exception, which lets an input under 5% of the aggregate be set aside, may be used only where it is documented; the worked example uses it twice and records both.
- ¶5 **AQ-FL4: tier direction.** Any tier cited in the account or its metadata states its scheme and direction (TG-0.7 Section 3.8), because some circulars use Tier 1 for the best data.

¶6 Local scales map onto the scheme. High, medium and low confidence become A, B and C. TG-4.1's "conditionally accepted" becomes C. Provisional, indicative and fallback values take status P, and modelled, benefit-transfer and TK-derived values take status E. "Data held but publication restricted" becomes X.

DRAFT

3.8 Worked Example: A Coastal Asset Account with Seeded Errors

¶1 This example is synthetic, and every number in it comes from one script run on one set of inputs. It is independent of the TG-3.1 worked example. An accounting area of 1,200 km² holds five ecosystem types, one demersal fish stock and a mangrove condition account; the period is one calendar year, and money is in USD thousand at current prices. The submitted accounts contain nine deliberate errors, E1 to E9, of kinds common in compiled accounts (Table 3.16.7).

Error	What the compiler did	Table	Caught by
E1	Booked 0.4 km² of mangrove converted to ponds as a reduction, with no destination	WE-2	AQ-ID3, AQ-ID4, AQ-ID5
E2	Booked seagrass loss of 0.9 km² and gain of 0.3 km² as one net conversion of 0.6 km²	WE-2	AQ-ID5
E3	Applied the mangrove condition index to the flow and again to the value	WE-6a	AQ-VA2, AQ-PM4
E4	Priced mangrove and seagrass carbon at a social cost of carbon	WE-1, WE-6a	AQ-VA6, AQ-VA3
E5	Entered the seagrass conversion ten times too large	WE-6a	AQ-UN1, AQ-EV2
E6	Added the stand-alone SEEA CF fish-stock value to the ecosystem total	WE-6c	AQ-ID6
E7	Valued the catastrophic fish loss inside the catch row and again on its own	WE-6b	AQ-PM1
E8	Computed stock status on total biomass instead of SSB	WE-5	AQ-FS1

Error	What the compiler did	Table	Caught by
E9	Quoted the conversion as a share of the mangrove type, not of the accounting area	WE-6d	AQ-UN4

¶2 *Table 3.16.7: Seeded errors and the checks that catch them.*

¶3 Two things in Table 3.16.7 are worth noticing. First, AQ-ID1 catches none of the errors: every submitted column balances. Second, several errors trip more than one check. E4 is the clearest case: a welfare price for carbon breaks the exchange-value rule, and by inflating carbon's share of the mangrove's annual flow value it also takes the asset outside the conditions under which the linear degradation shortcut may be used.

¶4 Three tables are printed here: the submitted monetary ecosystem account, which holds three of the errors; the QC log; and the same account corrected and flagged. **All 22 tables of the example** — the parameter register, the extent, change-matrix, condition and fish-stock accounts, every submitted and corrected table, the reconciliation and the uncertainty results — are in a companion page, with the QC log also as CSV.

> ¶5 ⚠ **As submitted — contains deliberate errors**
> ¶6 Table WE-6a is shown as a compiler submitted it. Do not copy it as a model.

¶7 **Table WE-6a: Monetary ecosystem asset account, as submitted (USD thousand)**

Accounting entry	Mangrove	Seagrass	Aquaculture ponds	Total
Opening value	**132,859**	**22,587**	**0**	**155,446**
Ecosystem enhancement	0	0	0	0
Ecosystem degradation	-5,066	..	..	-5,066
Ecosystem conversions (additions)	0	271	0	271
Ecosystem conversions (reductions)	-886	-8,131	0	-9,017
Catastrophic losses	0	0	0	0
Reappraisals	0	0	0	0
Revaluation	0	0	0	0
Closing value	**126,907**	**14,727**	**0**	**141,634**

DRAFT

¶8 *Subtidal sediment and Shelf waters: not valued (".."), so not shown. Aquaculture ponds: a confirmed zero, not a gap.*

¶9 *Table WE-6a: Monetary ecosystem asset account as submitted, containing errors E3, E4 and E5. Structure after TG-3.1 Table 4.*

¶10 The QC log is the record the reviewer reads (Table WE-7). One line is written per finding, naming the check, the cell and what was found; the fix is recorded against the same line.

¶11 **Table WE-7: QC log for the submitted set**

Check	Cell	Finding
AQ-ID3	WE-2 total closing	Closing total 1,199.6 km² against an EAA of 1,200.0 km²
AQ-ID4	WE-2 mangrove reductions	0.4 km² leaves mangrove with no destination type and no change to the EAA boundary
AQ-ID5	WE-2 mangrove conversions to	Account records 0.0 km²; matrix off-diagonals give 0.4 km²
AQ-ID5	WE-2 seagrass conversions to	Account records 0.6 km²; matrix off-diagonals give 0.9 km²

Check	Cell	Finding
AQ-ID5	WE-2 seagrass conversions from	Account records 0.0 km²; matrix off-diagonals give 0.3 km²
AQ-ID5	WE-3 ponds column	Column margin 15.4 km² against closing extent 15.0 km²
AQ-ID5	WE-2 ponds conversions from	Account records 0.0 km²; matrix off-diagonals give 0.4 km²
AQ-ID5	WE-2 sediment conversions to	Account records 0.0 km²; matrix off-diagonals give 0.3 km²
AQ-ID5	WE-2 sediment conversions from	Account records 0.6 km²; matrix off-diagonals give 0.9 km²
AQ-ID6	WE-6c total opening	Total exceeds the ecosystem types by 49,023, the stand-alone SEEA CF fish-stock value
AQ-ID6	WE-6c total closing	Total exceeds the ecosystem types by 50,839, the stand-alone SEEA CF fish-stock value
AQ-UN1	WE-6a seagrass conversions (reductions)	Implied 9,035 per km² against an opening unit value of 903 per km²: about 10 times
AQ-UN4	text N1	Text says 0.667; recomputed 0.033
AQ-PM1	WE-6b catch	Entry values 7,500 t; the physical account records 7,000 t
AQ-PM4	WE-6a mangrove degradation	Entry -5,066; index decline × PV of affected services gives -3,579
AQ-VA2	WE-6a mangrove opening	Value implies a condition factor of 0.533; the index is 0.730 (the index squared)
AQ-VA2	WE-6a mangrove closing	Value implies a condition factor of 0.470; the index is 0.685 (the index squared)
AQ-VA3	WE-6a mangrove degradation	Largest service (carbon) is 60% of annual flow value, not over 70%
AQ-VA6	WE-1 carbon price	Carbon priced on an SCC basis (USD 185 per tCO_2e); account cells hold exchange values
AQ-FS1	WE-5 B/BMSY	Ratio 1.91 computed on total biomass; on SSB it is 0.78
AQ-EV2	WE-6a seagrass conversions (reductions)	Entry -8,131; 0.9 km² × 903.5 gives -813

¶12 *Table WE-7: QC log. Thirteen checks fail; AQ-ID1 is not among them.*

¶13 Each correction follows the rule its check names; here the condition index enters once, carbon takes the exchange-value price, and the seagrass entry is re-derived from its unit value.

¶14 **Table WE-8c: Monetary ecosystem asset account, corrected and flagged (USD thousand)**

Accounting entry	Mangrove	Seagrass	Aquaculture ponds	Total
Opening value	**73,628** [C·E]	**14,529** [C·E]	**0** [A]	**88,157** [C·E]
Ecosystem enhancement	0	0	0	0
Ecosystem degradation	-3,579	..	..	-3,579
Ecosystem conversions (additions)	0	174	0	174
Ecosystem conversions (reductions)	-491	-523	0	-1,014
Catastrophic losses	0	0	0	0
Reappraisals	0	0	0	0
Revaluation	0	0	0	0
Closing value	**69,558** [C·E]	**14,180** [C·E]	**0** [A]	**83,738** [C·E]

DRAFT

¶15 *Subtidal sediment and Shelf waters: not valued ("‥"), so not shown. Aquaculture ponds: a confirmed zero, not a gap.*

¶16 *Table WE-8c: Monetary ecosystem asset account, corrected. Every valued cell except the confirmed zero for ponds is C·E, because the valuation ranges are wide (companion Table WE-10b).*

¶17 **What the example shows.** An account can be internally consistent and still wrong in six ways. It can be incomplete (E1); recorded net where gross is required (E2); in breach of a valuation rule (E3, E4); carrying an arithmetic slip (E5, E9); letting a total or a row take in an item that belongs elsewhere (E6, E7); or computing a derived figure on the wrong concept (E8). Each is caught by a check that recomputes from evidence outside the row being checked: the change matrix, the parameter register, the unit value, the physical account, or the stock assessment.

3.9 Uncertainty Assessment

¶1 TG-0.7 Section 3.4 names the four categories of uncertainty from SEEA EA paras 2.90–2.94, with their usual sources in ocean accounts [2], and this Circular does not repeat them. For asset accounts three physical sources dominate, and each has its method elsewhere: the area confidence interval from the accuracy assessment (AQ-EX2), the biomass and sustainable-yield intervals from the stock assessment (**TG-6.7** Section 3.6), and the standard error of the condition index (AQ-CO5). Valuation and future-price uncertainty are carried by the discount-rate grid (AQ-VA5) and by the range reported with every value.

¶2 **Method.** Uncertainty is quantified up a ladder, going as far as the data allow: a qualitative statement; an analytic, first-order combination in the manner of the GUM [11]; Monte Carlo propagation with at least 1,000 draws [12]; and a Bayesian treatment where priors are defensible. Intervals are reported at 95%. For an asset valued as the present value of its flows, the analytic step is

¶3

$$V = \sum_{t=1}^{T} \frac{Q_t \, p_t}{(1+r)^t}, \qquad \left(\frac{u_V}{V}\right)^2 \approx \left(\frac{u_Q}{Q}\right)^2 + \left(\frac{u_p}{p}\right)^2$$

DRAFT

¶4 where Q_t is the quantity, p_t the unit value, and u a standard uncertainty. The quadrature form assumes the quantity and the price are independent. Where they are not, as when a sustainable yield and a unit rent both depend on the same biomass, Monte Carlo over rent, sustainable yield, discount rate and horizon replaces it.

¶5 **Reporting.** Every monetary asset value is published with its range. The discount-rate grid (AQ-VA5) and the aggregation-rule sensitivity (AQ-CO4) go beside the account, not in an annex a user may not open.

¶6 **Modelled flows.** Where a service flow or a stock comes from a model, it is validated as **TG-4.11** Section 3.3 sets out. Until it is, it is flagged E (TG-4.5 Section 3.3.3). A biophysical model also conserves mass and area, the check the IPCC 2019 Refinement adds in Section 6.12 [13].

3.10 Review, Documentation and Release

¶1 **AQ-RV1: review.** A reviewer not involved in compilation reviews the evidence pack, recomputes a sample of cells and every headline figure, and logs each finding as closed or accepted [1]. Independent review is recommended, not a condition of release. For an asset account the reviewer should include a subject specialist for each part compiled: a stock-assessment scientist for the stock, a remote-sensing accuracy specialist for extent, and an environmental economist for valuation. Tier 3 makes this the standard (Section 3.2).

¶2 **AQ-RV2: documentation.** The four documentation categories of TG-0.7 Section 3.5 are completed for the account [2]. Beyond these, an asset account records the biomass concept, the assessment vintage and the valuation method; every other setting is in the parameter register (Section 3.3). Where an SDG indicator is derived from the account, the validation and quality fields of its metadata (4.d and 4.i to 4.k) are completed from the same record [14].

¶3 **AQ-RV3: archive.** Inputs, version-controlled code, the parameter register, the QC log and the outputs are archived together, sufficient for anyone to reproduce every published cell [1], [15].

¶4 **AQ-RV4: release gate.** The account is released when four conditions hold:

- ¶5 no blocking issue is open in the issue register;
- ¶6 no P-flagged value appears in headline text;
- ¶7 the statistical owner has signed off;
- ¶8 traditional knowledge is released only with the community authority's written approval.

¶9 Initial monetary releases are labelled experimental (AQ-EV4).

¶10 **The evidence pack.** Every account keeps a generic evidence pack: the scope and boundary statement (accounting area, period, boundaries, residence or territory, BSU level); the QA/QC plan with its tolerance register; the source register (every source, its owner, licence, date, method and coverage); and the archive manifest. Table 3.16.8 lists what an asset account adds; each item is produced during compilation, and none is written for the review.

Item	Contents
Balanced workbook	An identity column on every table; opening = previous closing
Depletion and degradation trace sheet	AQ-PM3 and AQ-PM4, cell by cell
Constant-price view	AQ-PM5
Valuation parameter register	Every parameter with its source, vintage and owner
Accuracy report	AQ-EX1 and AQ-EX2
Stock-assessment acceptance note	AQ-FS1 to AQ-FS6
Reconciliation and verification log	Table 3.16.6
Flagged table set	A grade and status on every cell; the lowest-flag derivation for aggregates
Uncertainty annex	Method, ranges and sensitivity grids
Revision and break log	Revision class, back-casts, breaks
Review record	Reviewer, sample recomputed, findings, dispositions

¶11 *Table 3.16.8: What an asset account adds to the generic evidence pack.*

DRAFT

3.11 Limitations

¶1 Four limits apply to everything above. First, a future SEEA quality framework may supersede parts of this Circular (Section 3.1). Second, the tolerances here are indicative. Several are GOAP proposals, not SEEA rules: the 0.20 decline and 70% share of the linear shortcut, the 80% and 75% accuracy thresholds, and the interim grade thresholds. Third, the monetary ecosystem checks inherit the status the UN Statistical Commission gave SEEA EA chapters 8 to 11: internationally recognised statistical principles and recommendations, and not a full statistical standard [16]. Fourth, coherence is not validity. An account can pass every check here and still rest on an ecological model that is wrong, and only verification against independent observation, repeated over cycles, tests that.

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

¶3 The structure of this Circular draws on the IPCC inventory guidelines' treatment of quality assurance, quality control and verification, on the UN National Quality Assurance Frameworks Manual, and on the IMF Data Quality Assessment Framework.

5. References

1. ¶1 IPCC (2006). *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 1, Chapter 6: Quality Assurance/Quality Control and Verification. Box 6.1 (definitions), Section 6.4 (roles, including the QA/QC coordinator), Section 6.5 (QA/QC plan and data-quality objectives), Section 6.6 and Table 6.1 (general QC procedures, including trend checks and sampling across years), Section 6.8 (QA by reviewers not involved in compilation), Section 6.10 (verification), Section 6.11.1 (internal documentation and archiving). IGES, Hayama. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_6_Ch6_QA_QC.pdf (https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_6_Ch6_QA_QC.pdf)
2. ¶2 United Nations et al. (2024). *System of Environmental-Economic Accounting — Ecosystem Accounting*, Statistical Papers Series F No. 124. Paras 2.86–2.89 (data quality; para 2.89 refers to the IMF DQAF), 2.90–2.94 (four categories of uncertainty), 2.95 (documentation of scope, definitions, methods and assumptions); the Section D overview, which suggests labelling initial monetary releases as experimental; and the research and development agenda, which lists data quality assessment frameworks as future work. Paragraph numbers are the same in the 2021 white-cover edition.
3. ¶3 United Nations et al. (2014). *System of Environmental-Economic Accounting 2012 — Central Framework*. Paras 1.54 and 6.7 (data confrontation), 6.64–6.70 (time series and revisions; para 6.68, revisions as standard practice), 6.86 (volume measures as data confrontation).
4. ¶4 United Nations (2019). *United Nations National Quality Assurance Frameworks Manual for Official Statistics*, Studies in Methods Series M No. 100. Requirement 15.1: "Source data, integrated data, intermediate results and statistical outputs are regularly assessed and validated." Welcomed by the UN Statistical Commission, decision 50/106.
5. ¶5 International Monetary Fund. *Data Quality Assessment Framework: Generic Framework*. Element 3.4, assessment and validation of intermediate data and statistical outputs (indicators 3.4.1–3.4.3). https://dsbb.imf.org/content/pdfs/dqrs_Genframework.pdf (https://dsbb.imf.org/content/pdfs/dqrs_Genframework.pdf)
6. ¶6 UNECE (2025). *Generic Statistical Business Process Model*, version 5.2. Sub-processes 5.3 (review and validate) and 6.2 (validate outputs).
7. ¶7 SEEA EA (2024), para 10.40: documenting all revisions to the accounts is strongly recommended for data quality assessment.
8. ¶8 SEEA EA (2024), para 4.17: no distinct entry is recorded for revisions to extent; the entries for opening and closing extent and for additions and reductions are altered, and it may be appropriate to show the size of the revision for analysis and dissemination.
9. ¶9 SEEA EA (2024), para 10.38: reappraisals are recorded when updated information permits a reassessment of the expected condition of ecosystem assets or the future demand for their services.
0. ¶10 Olofsson, P., Foody, G. M., Herold, M., Stehman, S. V., Woodcock, C. E. and Wulder, M. A. (2014). Good practices for estimating area and assessing accuracy of land change. *Remote Sensing of Environment* 148, 42–57. https://doi.org/10.1016/j.rse.2014.02.015 (https://doi.org/10.1016/j.rse.2014.02.015)
1. ¶11 JCGM (2008). *Evaluation of measurement data — Guide to the expression of uncertainty in measurement* (GUM), JCGM 100:2008.
2. ¶12 JCGM (2008). *Evaluation of measurement data — Supplement 1 to the GUM: Propagation of distributions using a Monte Carlo method*, JCGM 101:2008.
3. ¶13 IPCC (2019). *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 1, Chapter 6, Section 6.12: Use and reporting of models, including conservation of mass and land area.
4. ¶14 United Nations Statistics Division. SDG indicator metadata template, fields 4.d (validation) and 4.i–4.k (quality management, quality assurance, quality assessment). See, for example, the metadata for indicator 14.5.1.
5. ¶15 United Nations (2022). *Guidelines on Biophysical Modelling for Ecosystem Accounting*, Chapter 7: Data quality for biophysical modelling. Paras 359–369 (accuracy, reliability and model validation), 374–375 (provenance and version control).
6. ¶16 United Nations Statistical Commission, decision 52/108 (March 2021), as recorded in the Preface to SEEA EA (2024): chapters 8 to 11 "describe internationally recognized statistical principles and recommendations for the valuation of ecosystem services and assets". The Commission adopted chapters 1 to 7 as an international statistical standard.

DRAFT

DRAFT