

Pelagic and Open Ocean Accounting

Provides guidance on compiling accounts for pelagic and open ocean ecosystems.

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ABOUT THIS CIRCULAR

RECOMMENDED CITATION

Pelagic and Open Ocean Accounts: Rationale, Design, and Implementation (2026 SEA-FT), and Benefit-sharing arrangements for marine genetic resources require accounts extending beyond national jurisdiction.

Accounting, TG-6.5, v0.8.1). GOAP Secretariat.

<https://guidance.oceanaccounts.org/circulars/section-6/6-5-pelagic-open-ocean/>

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Pelagic primary productivity measurements feed into [TG-2.1 Biophysical Indicators](#) and biological carbon pump quantification connects to [TG-2.8 Climate Change Indicators](#). The foundational

concepts for Ocean Accounts are established in [TG-0.1 General Introduction to Ocean Accounts](#).

Physical and monetary asset accounting methodology is in [TG-3.1 Asset Accounts](#). As an Emerging circular, this document should be reviewed in two to three years as methodologies mature.

① Framework Position

This Circular owns the delineation and accounting of the open-ocean water column, IUCN GET biome M2 (M2.1 epipelagic through M2.4 abyssopelagic, and M2.5 sea ice), where the SEEA EA's seabed-based delineation does not apply. It also owns the treatment of migratory and straddling stocks: the recordable national asset is the agreed access right, not the biomass in the water.

It cross-refers for the account structure ([TG-3.1](#)) and for the UNCLOS zones, ABNJ asset boundary and BBNJ provisions, which are owned by [TG-6.6](#) Section 3.1 and apply to the water column as they do to the seabed. Stock assessment inputs come from [TG-6.7](#).

M1.9 upwelling zones sit in the Marine Shelf biome and are outside this Circular. No circular in this edition covers them; Section 3.1 states the interim treatment.

1. Outcome

¶1 This Circular provides guidance on compiling accounts for pelagic and open ocean ecosystems, the water column environments that extend seaward to the high seas and downward to the abyssal depths. As an Emerging circular, it acknowledges that methodologies for pelagic ocean accounting remain less developed than for coastal and benthic ecosystems, with substantial uncertainties in spatial delineation, stock measurement, and the attribution of assets and services across jurisdictional boundaries¹. Pelagic ecosystems present distinctive accounting challenges. They are defined by water masses rather than fixed substrates, primary production occurs diffusely throughout enormous volumes, and key species are highly migratory across multiple jurisdictions. Much of the domain also lies beyond national jurisdiction, in high seas areas governed by the freedom of the seas principle, whilst the seabed beneath is subject to the common heritage of mankind regime².

¶2 Key decision use cases include quota allocation for tuna and billfish managed through Regional Fisheries Management Organisations (RFMOs), ocean carbon sink quantification to measure the biological carbon pump for nationally determined contributions (NDCs) under the Paris Agreement³, and BBNJ Agreement implementation, where area-based management tools, environmental impact assessments, and benefit-sharing arrangements for marine genetic resources require accounts extending beyond national jurisdiction⁴.

¶3 Pelagic primary productivity measurements feed into **TG-2.1 Biophysical Indicators** and biological carbon pump quantification connects to **TG-2.8 Climate Change Indicators**. The foundational concepts for Ocean Accounts are established in **TG-0.1 General Introduction to Ocean Accounts**. Physical and monetary asset accounting methodology is in **TG-3.1 Asset Accounts**. As an Emerging circular, this document should be reviewed in two to three years as methodologies mature.

¶4 ⓘ Framework Position

¶5 This Circular owns the delineation and accounting of the **open-ocean water column, IUCN GET biome M2** (M2.1 epipelagic through M2.4 abyssopelagic, and M2.5 sea ice), where the SEEA EA's seabed-based delineation does not apply. It also owns the treatment of **migratory and straddling stocks**: the recordable national asset is the agreed access right, not the biomass in the water.

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¶7 M1.9 upwelling zones sit in the Marine Shelf biome and are outside this Circular. No circular in this edition covers them; Section 3.1 states the interim treatment.

2. Requirements

¶1 This Circular requires familiarity with:

- ¶2 **TG-0.1 General Introduction to Ocean Accounts** – conceptual framework, key components, and spatial scope definitions for pelagic ecosystems within and beyond national jurisdiction.
- ¶3 **TG-3.1 Asset Accounts** – methodology for physical and monetary asset accounts, including aquatic resources, ecosystem assets, and the treatment of assets not clearly associated with specific seabed areas.
- ¶4 **TG-6.7 Fisheries Stock Assessment** – stock assessment concepts (biomass, natural mortality M, fishing mortality F, recruitment, VPA, close-kin mark-recapture) required before attempting Steps 4 and 5 of the compilation procedure.

¶5 Readers may also benefit from:

- ¶6 **TG-6.6 Deep Sea and Seabed Accounting** – complementary guidance on benthic ecosystems underlying pelagic waters.
- ¶7 **TG-2.8 Climate Change Indicators** – carbon sequestration and climate regulation services from pelagic ecosystems.

¶8 **Readiness and sequencing.** Whether a country is positioned to compile this account at all – mandate, data architecture, capacity and the order in which to build – is assessed under **TG-0.8 Implementation Readiness Assessment**, and is not restated here.

3. Guidance Material

¶1 The pelagic ocean is the largest biome on Earth, comprising the open-ocean water column across all latitudes and spanning depths from the surface to nearly 11 kilometres in the deepest trenches⁵. Unlike coastal and benthic ecosystems where spatial units can be delineated by substrate or shoreline, pelagic ecosystems are structured by the physical and chemical properties of water masses: temperature, salinity, light penetration, oxygen concentration, and nutrient availability.

3.1 Spatial Delineation

***Scope boundary:** TG-6.5 covers only open-ocean M2 biome units (M2.1 Epipelagic, M2.2 Mesopelagic, M2.3 Bathypelagic, M2.4 Abyssopelagic, M2.5 Sea ice). M1.9 upwelling zones fall under the Marine Shelf biome (M1) and are outside TG-6.5. No circular in this edition covers the M1 shelf ecosystems other than M1.1 (TG-6.3), M1.2 and M1.6 (TG-6.4) and M1.3 (TG-6.1); until one is issued, compile M1.9 using the generic ecosystem asset method in **TG-3.1 Asset Accounts** with condition variables selected under **TG-4.8** and **TG-4.9**, and document the departure. Open-ocean upwelling features (e.g., intertropical convergence) are included within M2.1. See **TG-6.6 Deep Sea and Seabed Accounting** for the shelf/benthic boundary treatment.*

¶1 Spatial delineation must address three considerations: vertical zonation of the water column, horizontal biogeographic regions, and jurisdictional boundaries under international law.

Vertical zonation

¶1 Pelagic ocean waters are classified within the IUCN Global Ecosystem Typology as biome **M2**. For the GET realm/biome/EFG hierarchy and the national crosswalk obligation, see **TG-4.1 Remote Sensing and Geospatial Data** Section 3.2.4.⁶ Table 3.1.1 summarises the M2 functional groups relevant to this Circular.

Functional group	Description
M2.1 Epipelagic ocean waters (0–200m)	The sunlit surface layer where photosynthesis occurs, supporting primary production by phytoplankton and the highest biodiversity and biomass of pelagic organisms ⁷ , ⁸ .
M2.2 Mesopelagic ocean waters (200–1,000m)	The “twilight zone” receiving insufficient light for photosynthesis, dominated by detritivores and predators, and characterised by high biomass of small fishes and extensive diel vertical migration ⁹ , ¹⁰ .
M2.3 Bathypelagic ocean waters (1,000–3,000m)	Dark waters dependent on organic fallout from above, with low biomass, long-lived organisms, and truncated food webs ¹¹ .

Functional group	Description
M2.4 Abyssopelagic ocean waters (3,000–6,000m)	Extreme depths with low biomass and specialised fauna adapted to high pressure and nutrient scarcity ¹² .
M2.5 Sea ice	The seasonally frozen surface of polar oceans supporting specialised ice-associated communities ¹³ .

¶2 For practical accounting purposes, the epipelagic zone is of primary importance as it contains most commercially exploited fish stocks, supports virtually all primary production, and generates the ecosystem services of greatest current economic relevance¹⁴. The mesopelagic zone is now recognised as a large carbon reservoir and a potential future fishery resource. The SEEA EA 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”¹⁵. For the open ocean, where the seabed-based delineation approach recommended by SEEA EA is less suitable, alternative approaches are summarised in Table 3.1.2.

Approach	Description
Water-mass-based delineation	Defining ecosystem units by oceanographic characteristics such as temperature, salinity, and circulation patterns.
Biogeographic provinces	Using established marine biogeographic classifications such as Longhurst provinces ¹⁶ .
Depth-zone layers	Treating vertical zones as separate accounting units overlaying the horizontal extent.

¶3 Countries operationalising pelagic ecosystem delineation within their EEZs may find it practical to begin with Longhurst biogeographic provinces (for horizontal delineation) combined with GET M2 depth-zone layers (for vertical stratification), and to focus on the epipelagic zone alone for initial implementation.

Biogeographic regions

¶1 Productive pelagic regions include eastern boundary upwelling systems (Canary, Benguela, California, and Humboldt currents), tropical and subtropical gyres, polar and subpolar regions, and frontal zones and convergences. The GET recognises coastal upwelling zones as functional group M1.9 within the Marine Shelf biome¹⁷, whilst weaker open-ocean upwelling (e.g., intertropical convergence zone) falls within M2.1.

Jurisdictional boundaries

¶1 The UNCLOS maritime zones, the SEEA CF asset-boundary treatment of areas beyond national jurisdiction, the extended continental shelf claim states, and the BBNJ Agreement provisions are set out once in **TG-6.6 Deep Sea and ABNJ Accounting** Section 3.1, which owns them for the publication^{18, 19, 20, 21, 22}. That treatment applies to the pelagic water column exactly as it does to the seabed.

¶2 One rule is pelagic-specific and is stated here because it has no seabed equivalent. Stocks that migrate across zones, straddle a boundary, or complete their life cycle on the high seas are not excluded from the national asset boundary merely because the fish are outside the EEZ for part of the year. The SEEA CF provides that “when exploitation control over migrating and straddling fish stocks, and fish stocks that complete their life cycle in international waters (high seas), has been established and the access rights of a country to them are defined in international agreements, that portion of agreed access rights to those aquatic resources can be considered to belong to the country”²³. The recordable asset is therefore the **agreed access right**, sized by the allocation instrument – an RFMO quota share, a bilateral access agreement – and not the biomass in the water.

Section 3.3 below applies this to migratory species, and **TG-6.7 Fisheries Accounting** gives the stock-assessment inputs the allocation is derived from.

¶3 For how jurisdictional boundaries interact with extent and condition accounts, see **TG-0.1 General Introduction to Ocean Accounts**.

3.2 Extent and Condition

Extent measurement

¶1 Unlike terrestrial or benthic ecosystems measured in hectares, pelagic ecosystem extent may be expressed in multiple dimensions:

- ¶2 **Surface area** – the horizontal extent of water masses or biogeographic provinces (km²)
- ¶3 **Volume** – the three-dimensional extent of depth zones (km³)
- ¶4 **Mixed metrics** – surface area combined with characteristic depth range

¶5 For national accounts within the EEZ, extent may be calculated as the area of the EEZ multiplied by relevant depth zones. For initial implementation, the epipelagic zone is the most tractable focus, as extent changes there are detectable through satellite-observable indicators such as sea surface temperature and chlorophyll-a fronts. Changes in pelagic extent reflect continuous oceanographic variation (water mass boundary shifts, thermocline movement, photic zone depth changes) rather than the discrete conversions characteristic of benthic ecosystems.

¶6 Table 1 presents an illustrative structure for a pelagic ecosystem extent account (Pacific SIDS, 500,000 km² EEZ, two depth zones). Derivation: epipelagic 500,000 km² x 0.2 km = 100,000 km³, and mesopelagic 500,000 km² x 0.8 km = 400,000 km³.

Accounting entry	M2.1 Epipelagic	M2.2 Mesopelagic	Total
Opening extent (km ³)	100,000	400,000	500,000
Changes			
– Water mass shifts	-500	+500	0
– Depth zone changes	+200	-200	0
Net change	-300	+300	0
Closing extent (km ³)	99,700	400,300	500,000

¶7 *Table 1: Illustrative structure for pelagic ecosystem extent account within EEZ (Pacific SIDS, 500,000 km² EEZ)*

¶8 **Crosswalk to SEEA EA standard extent change categories.** The change categories used here reflect the continuous rather than discrete nature of pelagic extent changes.

Pelagic-specific category	SEEA EA standard category	Notes
Water mass shift (climate-driven warm pool expansion/contraction)	Natural reduction / natural expansion	Where a net volume change of a water mass type occurs
Depth zone reclassification (thermocline movement with no net volume change)	Reclassification (not an extent change)	Per SEEA EA para 6.14, statistical reclassifications are recorded separately from extent losses and gains
Sea ice seasonal/multi-year change (M2.5)	Natural reduction / natural expansion	Where multi-year ice extent shifts

¶9 Thermocline-driven movements that shift volume between depth zones without changing total water column volume should be recorded as reclassifications, not as paired losses and gains, to preserve consistency with SEEA EA para 6.12–6.15.

¶10 **Working from a regional habitat map.** Compilers whose extent data come from a regional seas habitat product rather than from oceanographic fields should check whether that product carries pelagic classes at all. The first ecosystem accounts compiled for a regional sea – the preliminary OSPAR accounts for the North-East Atlantic – recorded extent for six seabed classes and no pelagic class, because the seabed map available (EUSeaMap, on the EUNIS classification then published) resolved substrate rather than water column, and its authors noted the resulting two-dimensional treatment as a principal limitation to be addressed by extending accounts into the water column²⁴. The 2022 revision of EUNIS disaggregated marine habitats into benthic and pelagic components, so a regional map may now support a pelagic extent account where an earlier vintage of the same map could not. Two consequences for compilation:

- ¶11 A regional habitat map that predates the benthic/pelagic split supports the seabed account of **TG-6.6 Deep Sea and Seabed Accounting** but not the pelagic extent account of this Section. Compile pelagic extent from oceanographic fields and biogeographic provinces per Section 3.1 instead of forcing a benthic classification into the water column.
- ¶12 Where both a benthic and a pelagic classification are available from the same regional product, they remain separate extent accounts over the same footprint, per the double-counting rule in Section 3.4. Record the vintage of the classification used in account metadata, as the class definitions have changed.

Condition variables

¶1 The SEEA EA condition framework applies to pelagic ecosystems with appropriate variable selection. Key condition characteristics include²⁵:

¶2 Abiotic characteristics:

- ¶3 Sea surface temperature and thermal stratification
- ¶4 Ocean acidification (pH, aragonite saturation)
- ¶5 Dissolved oxygen concentration (with attention to oxygen minimum zones)
- ¶6 Nutrient concentrations (nitrate, phosphate, silicate, iron)
- ¶7 Salinity and density structure

¶8 Biotic characteristics:

- ¶9 Chlorophyll-a concentration as a proxy for phytoplankton biomass²⁶
- ¶10 Primary productivity rates (net primary production, NPP)
- ¶11 Zooplankton biomass and community composition
- ¶12 Fish biomass and species composition
- ¶13 Marine mammal and seabird abundance

¶14 Functional characteristics:

- ¶15 Primary productivity (carbon fixation rates)
- ¶16 Export production (flux of organic matter to depth)
- ¶17 Community structure and trophic organisation

¶18 The epipelagic zone's primary production "largely by diatoms, accounts for around half of all global carbon fixation"²⁷. Productivity metrics are therefore of particular importance in pelagic condition accounts. The mesopelagic zone contains fish biomass estimated at possibly "two orders of magnitude larger than global fisheries landings"²⁸, though precise quantification remains uncertain.

¶19 For how condition variables translate into indicators, see **TG-2.1 Biophysical Indicators**.

Reference conditions

¶1 Establishing reference conditions for pelagic ecosystems is complicated by high natural variability from climate oscillations (El Nino–Southern Oscillation, Pacific Decadal Oscillation) and the lack of historical baseline data. Possible approaches include pre-industrial baselines (for temperature, acidification), model-based reference states from ecosystem models, and policy-based targets established under regional fisheries agreements. Given these challenges, condition accounts may need to focus on tracking trends and rates of change rather than departures from fixed reference conditions.

3.3 Migratory Species

¶1 Highly migratory species present particular challenges for asset accounting, as their distribution spans multiple EEZs and the high seas. The treatment of aquatic resources in asset accounts is addressed in **TG-3.1 Asset Accounts** Section 3.4.1. This section provides supplementary guidance specific to highly migratory pelagic species.

UNCLOS provisions

¶1 Article 64 of UNCLOS requires coastal States and other fishing States to cooperate through appropriate international organisations to ensure conservation and optimal utilisation of highly migratory species throughout the region, both within and beyond the EEZ²⁹. UNCLOS Annex I lists highly migratory species. Table 3.3.1 summarises the principal groups³⁰.

Group	Species included
Tunas	Albacore, bluefin (Atlantic, Pacific, southern), bigeye, skipjack, yellowfin, blackfin, little tuna, frigate mackerel.
Billfish	Marlins, sailfishes, swordfish.
Other pelagic fish	Sauries, pomfrets, dolphinfish (mahi-mahi).
Oceanic sharks	Various families including Carcharhinidae, Alopiidae, Isurida (now Lamnidae).
Cetaceans	All whale and dolphin families.

¶2 The 1995 UN Fish Stocks Agreement further elaborates obligations for straddling and highly migratory stocks, requiring cooperation through RFMOs³¹.

Accounting approaches

¶1 The SEEA CF provides that “migrating and straddling fish stocks are considered to belong to a country during the period when those stocks inhabit its EEZ”³². Alternative attribution approaches are summarised in Table 3.3.2.

Approach	Description
Proportional allocation	Attributing stock shares based on time spent in each EEZ or catch proportions.
RFMO-based allocation	Using catch quotas allocated by regional management bodies as the basis for national asset shares.
Flag State attribution	Attributing catches to the flag State of the harvesting vessel (as done for production in the SNA).
Ecosystem-based accounts	Maintaining accounts at the scale of the stock’s range rather than national boundaries.

¶2 For highly migratory species managed under RFMOs, quota allocations provide a practical basis for attributing asset shares, since “that portion of agreed access rights to those aquatic resources can be considered to belong to the country”³³. RFMO quotas are expressed as catch limits (flows) rather than stock shares (assets). Converting to asset shares requires (1) total stock biomass from the RFMO stock assessment, (2) each country’s proportional quota share, and (3) the application of that share to the total stock estimate to derive attributed asset value. This conversion intro-

duces uncertainties from stock assessment precision, the catch-share-as-asset-share assumption, and temporal mismatch.

Handling temporal mismatch between stock assessments and accounting periods

¶1 RFMO stock assessments are conducted every 3 to 5 years. In years without a new assessment, compilers should:

1. ¶2 Use the most recent assessment as the opening stock for the accounting period.
2. ¶3 Update to a closing stock using the stock account flow identity: closing stock = opening stock + natural growth – catch – natural mortality, with growth, M, and F parameters carried forward from the last assessment.
3. ¶4 Flag the resulting entry as “model-projected” rather than “assessment-based” in account metadata.
4. ¶5 When a new stock assessment becomes available, retrospectively revise the affected accounting periods and record the change as a statistical revision (reappraisal) consistent with SEEA CF para 5.393.

¶6 For revision protocols, see **TG-0.7 Quality Assurance**.

¶7 Table 2 presents an approach to structuring highly migratory species asset accounts using RFMO-based allocation.

Accounting entry	National EEZ stock	High seas allocation (quota-based)	Total attributed
Opening stock (tonnes)	8,200	4,100	12,300
Additions			
– Natural growth	1,200	600	1,800
– Immigration/movement in	500	0	500
– Reappraisals	0	0	0
Reductions			
– Catch – landings (by residents)	850	520	1,370
– Catch – discards (by residents)	50	30	80
– Catch (by non-residents, licensed)	200	0	200
– Emigration/movement out	400	0	400
– Natural mortality	800	400	1,200
– Reappraisals	0	0	0
Closing stock (tonnes)	7,600	3,750	11,350

¶8 *Table 2: Illustrative structure for highly migratory species asset account with synthetic values*

¶9 **Methodological note.** The “Total attributed” column sums the National EEZ stock (physical biomass) and the High seas allocation (quota-based financial asset share). These two quantities are not dimensionally homogeneous: the EEZ column records physical fish location, whilst the high seas column records a treaty-defined access right. Compilers should treat the “Total attributed” column as a memo aggregate only. Immigration and emigration entries appear only in the National EEZ stock column: movement out of the EEZ does not transfer biomass into the quota-based high seas allocation, as that allocation is defined by treaty share rather than physical residence. Changes to the quota share (renegotiated allocations) are recorded as reappraisals, not as flows. The approach chosen should be documented in metadata.

Cetaceans and marine mammals

¶1 UNCLOS Article 65 addresses marine mammals separately, requiring States to cooperate for conservation through appropriate international organisations³⁴. Unlike fish stocks, cetaceans are not typically harvested commercially, so their treatment in accounts focuses on ecosystem condition, ecosystem services (tourism, existence value), and biodiversity indicators. For whale watching and marine mammal tourism, see **TG-2.4 Ecosystem Goods and Services**.

3.4 Accounting Boundaries for Pelagic Activities

¶1 Table 3 summarises the principal boundary challenges and their treatment, drawing on UNCLOS jurisdictional provisions, SEEA CF asset boundary rules, and SNA residence principles.

Accounting Challenge	Treatment Approach	Data Implications
Migratory species crossing EEZ	Allocate by RFMO quota share (recommended); or by residence time / catch location where quotas unavailable (see Section 3.3)	VMS data, tagging studies, RFMO quota records
Stocks shared with neighbours	Joint stock assessment	Regional cooperation
High seas activity by residents	Include in national accounts	Flag state reporting
High seas activity by non-residents	Exclude from national production	Distinguish by flag
Water column vs seabed ecosystems	Separate extent accounts	3D spatial data

¶2 *Table 3: Pelagic accounting boundary treatments*

¶3 **Migratory species crossing EEZ boundaries** are allocated to the EEZ in which they reside at the accounting date or, where continuous tracking is unavailable, in proportion to catch location data from vessel monitoring systems (VMS) and scientific tagging programmes.

¶4 **Stocks shared with neighbouring countries** require joint stock assessments through bilateral or multilateral arrangements. Each country's asset share reflects its agreed access rights.

¶5 **High seas activity by resident economic units** is included in national production accounts per the SNA residence principle: output of fishing vessels on the high seas is attributed to the flag State's economy.

¶6 **High seas activity by non-resident units** (foreign-flagged vessels) is excluded from national production but may appear where foreign vessels operate under access agreements within the EEZ. AIS data supports flag state identification.

¶7 **Water column versus seabed ecosystems** are treated as separate extent accounts to avoid double-counting. The relationship between these overlapping accounts is addressed in **TG-6.6 Deep Sea and Seabed Accounting**.

3.5 Ecosystem Services

¶1 Pelagic ecosystems generate a range of ecosystem services, though many are difficult to measure and value. This section should be read in conjunction with **TG-2.4 Ecosystem Goods and Services** for the general framework. For valuation approaches, see **TG-1.9 Valuation**.

Provisioning services

¶1 **Fisheries production** is the dominant provisioning service. The SEEA AFF distinguishes "Pelagic fish, including Tunas, bonitos, billfishes" and "Other pelagic fish"³⁵. For pelagic fisheries accounting, see **TG-3.2 Flows from the Environment to the Economy** and **TG-6.7 Fisheries Stock Assessment**.

¶2 **Landings data will not attribute the service to an ecosystem type**. Reported landings – whether national, FAO or RFMO – carry a fleet, a species and a management area, not the ecosystem.

tem that supplied the catch. In the preliminary OSPAR regional-sea accounts, fish provisioning was compiled from FAO landings and could not be assigned to any individual ecosystem type; the flow was recorded against the full set of ecosystem classes as a group, and the compilers identified the absence of spatially explicit links between landings and ecosystems as one of the two gaps blocking further extension of the accounts²⁴. For pelagic accounts this constraint is structural rather than incidental: catch is taken from a moving stock over a wide area, and no realistic reporting improvement will locate a landing in a single water mass. Recommended treatment:

- ¶3 Record the service against the set of pelagic ecosystem types plausibly supplying the stock, labelled as a group, rather than apportioning it to one type on an unstated assumption.
- ¶4 Where an apportionment is required, derive it from VMS or observer effort distribution rather than from landings, and disclose the effort series and the period used.
- ¶5 Do not read a service flow recorded against a group of ecosystem types as evidence of the condition of any one of them.

¶6 **Access licence fees vs ecosystem service supply.** A common compilation issue for SIDS whose primary ocean revenue is access fee income is the distinction between the ecosystem service flow value and the economic transaction value represented by licence fees.

Item	Conceptual nature	Recording location
Ecosystem service supply (sustainable yield x resource rent per tonne)	The value of the provisioning service generated by the stock	SEEA EA ecosystem service supply table; physical and monetary ecosystem service accounts
Access licence fee receipts from foreign fleets	A payment for the right to exploit the provisioning service; an economic transaction	SNA current account (current transfers / service exports under the balance of payments); recording basis described in TG-3.2 Flows from the Environment to the Economy

¶7 Licence fees should not be added to the ecosystem service supply value, as that addition would double-count the underlying provisioning service. The resource rent component embedded in the licence fee is conceptually part of the ecosystem service value, but the fee itself is recorded as a current transaction (see SEEA EA para 8.40–8.42 and SEEA CF para 5.395).

¶8 **Resource rent does not track the stock.** Compilers should expect the monetary series for fish provisioning to move independently of, and sometimes opposite to, the physical series. The OSPAR accounts recorded 8.33 Mt landed valued at EUR 2,846 million in one year against 9.15 Mt landed valued at EUR 1,728 million in another, because resource rent per tonne is a residual sensitive to fuel and input prices rather than to the state of the stock²⁴. The consequence is that the monetary account should be read for relative change over a run of years and not as a level, and that a fall in the monetary value of the provisioning service is not evidence of stock decline. Where the physical and monetary series diverge in direction, state the input-price movement responsible in account metadata.

¶9 **Genetic resources** from pelagic organisms represent an emerging provisioning service category. The BBNJ Agreement establishes a benefit-sharing framework for marine genetic resources in areas beyond national jurisdiction³⁶.

¶10 **Mesopelagic resources as a prospective asset.** Mesopelagic fish biomass may be two orders of magnitude larger than global fisheries landings (estimate carries high uncertainty from acoustic backscatter conversion). As commercial exploitation has not yet emerged at scale, the recommended treatment is:

- ¶11 Where no commercial exploitation control has been established, the monetary value within the SEEA CF asset boundary is zero (per SEEA CF para 5.6 asset recognition criterion requiring exploitation control).

- ¶12 Countries may include mesopelagic stock in a physical-only experimental account recording biomass estimates with explicit uncertainty ranges, clearly distinguished from core SEEA EA/CF tables.
- ¶13 When commercial exploitation begins and exploitation control is established, the resource moves into the core asset account.

¶14 See **TG-3.1 Asset Accounts** on the asset boundary criterion and contingent resources.

Regulating services

¶1 **Climate regulation through carbon sequestration.** Primary production in the epipelagic zone fixes atmospheric CO₂ into organic matter. A portion is exported to depth through sinking particles, vertical migration, and physical mixing. These processes, collectively the “biological pump”³⁷, sequester carbon from the atmosphere for centuries to millennia. Diel vertical migration in the mesopelagic zone enhances this transport³⁸.

¶2 Quantifying carbon sequestration services requires estimates of net primary production rates, export production (fraction of NPP exported below the mixed layer), and sequestration efficiency (fraction reaching long-term storage depths)³⁹. Attribution to national accounts raises challenges, as the service is generated by global ocean circulation that is not confined to any single EEZ, whilst the benefits are global rather than national. For initial compilations, recording carbon sequestration within the EEZ as a nationally generated service is the recommended default, with metadata noting that benefits are global and the recording does not imply exclusive national claim. For guidance on integrating carbon sequestration into accounts, see **TG-2.8 Climate Change Indicators**.

¶3 **Nutrient cycling** through upwelling and vertical mixing redistributes nutrients that support productivity throughout the ocean and in coastal zones.

Cultural services

¶1 Pelagic cultural services include marine scientific research and oceanographic monitoring, whale watching and recreational fishing, and ocean cruising. Existence and bequest values attach to healthy ocean ecosystems and charismatic marine megafauna (whales, sharks, sea turtles). For measuring cultural ecosystem services, see **TG-2.4 Ecosystem Goods and Services**.

3.6 Data and Methods

¶1 Pelagic ecosystems present data challenges due to their remoteness, vast scale, and dynamic nature.

Satellite oceanography

¶1 Remote sensing provides essential data for pelagic ecosystem monitoring at scales not achievable by in situ methods. Principal satellite data streams include⁴⁰ (1) ocean colour (MODIS, VIIRS, Sentinel-3 OLCI) for chlorophyll-a and primary productivity, (2) sea surface temperature from thermal infrared and microwave sensors, (3) sea surface height from altimetry for circulation, eddies, and fronts, and (4) sea ice extent from passive microwave sensors. Limitations include penetration limited to the near-surface, cloud cover affecting visible-band sensors, and the need for atmospheric correction. For detailed guidance on remote sensing in ocean accounts, see **TG-4.1 Remote Sensing Data**.

In situ oceanography

¶1 Principal in situ platforms are (1) research vessels (CTD profiles, water sampling, net sampling), (2) Argo floats (global array of >4,000 profiling floats to 2,000m), (3) Biogeochemical Argo (oxygen, nitrate, pH, chlorophyll, particle sensors), and (4) moorings and buoys for time-series observations. The Global Ocean Observing System (GOOS) coordinates international observation with Essential Ocean Variables (EOVs) relevant to ecosystem accounting.

Fish stock assessment

¶1 Pelagic fish stock assessment employs methods distinct from demersal fisheries due to species mobility and aggregating behaviour: acoustic surveys (echosounders estimating biomass of schooling fish), electronic tagging and tracking (archival, satellite tags for migration patterns), virtual population analysis (age-structured models from catch-at-age data), and close-kin mark-recapture (genetic methods for absolute abundance). For detailed guidance on stock assessment methods, see **TG-6.7 Fisheries Stock Assessment**. For survey methodologies, see **TG-4.2 Survey Methods**.

Model-based approaches

¶1 Pelagic ecosystem accounting may rely substantially on models: biogeochemical models (primary production, carbon cycling, nutrient dynamics), ecosystem models such as Ecopath with Ecosim and Atlantis (trophic interactions and biomass flows), species distribution models (habitat suitability and distribution shifts), and stock assessment models. Best practice involves ensemble approaches, uncertainty quantification, and validation against available observations.

Uncertainty characterisation

¶1 Key sources of uncertainty include structural uncertainty in model formulations, parametric uncertainty in model calibration, observational uncertainty in sparse in situ validation data, and spatial extrapolation from point observations to large pelagic domains. Compilers should report confidence intervals or uncertainty ranges where feasible, use ensemble modelling to capture structural uncertainty, and clearly distinguish between observation-based and model-derived entries in published accounts. See **TG-0.7 Quality Assurance** for systematic guidance on uncertainty communication.

3.7 Compilation Procedure and Worked Example

Step 1: Define spatial accounting units

¶1 **Action:** Delineate the pelagic accounting area within the EEZ, distinguishing depth zones and, where relevant, biogeographic provinces.

¶2 Data requirements:

- ¶3 Bathymetric data to determine water column depth
- ¶4 Oceanographic data (temperature, salinity) to identify water mass boundaries
- ¶5 EEZ boundary data from national maritime authorities

¶6 **Output:** A spatial framework defining accounting units (e.g., "Epipelagic zone within EEZ", "Mesopelagic zone within EEZ").

Step 2: Compile extent accounts

¶1 **Action:** Measure the opening and closing extent of each pelagic ecosystem type, recording changes during the accounting period.

¶2 Data requirements:

- ¶3 Volume calculations from bathymetry and depth zone definitions
- ¶4 Time-series satellite data for sea surface temperature and chlorophyll-a to detect water mass shifts
- ¶5 Oceanographic model outputs for thermocline depth changes

¶6 Calculation:

- ¶7 Epipelagic extent (km³) = EEZ surface area (km²) x mean depth of photic zone (km)
- ¶8 Record changes as water mass boundary shifts or depth zone reclassifications

¶9 **Output:** Physical extent account showing opening extent, changes (water mass shifts, depth zone changes), and closing extent by ecosystem type.

Step 3: Compile condition accounts

¶1 **Action:** Measure condition variables for each ecosystem type at representative monitoring stations.

¶2 **Data requirements:**

- ¶3 Satellite-derived chlorophyll-a and SST (for epipelagic zone)
- ¶4 Argo float profiles for subsurface temperature, salinity, dissolved oxygen
- ¶5 Research vessel surveys for nutrient concentrations and plankton biomass
- ¶6 Stock assessment outputs for fish biomass

¶7 **Calculation:**

- ¶8 Condition variables are normalised using the standard formula defined in **TG-2.1 Biophysical Indicators for Ocean Accounts** Section 3.4.1. For pelagic negative indicators (e.g., SST anomaly, acidification stress), transform the variable to its negative form (e.g., use $-1 \times$ SST anomaly) so that the standard formula applies directly. See the SST worked cell in the worked example below.
- ¶9 Document reference condition selections and the treatment of any negative indicators.

¶10 **Output:** Condition variable account with raw measurements and normalised indicators for each ecosystem type. Composite indices are optional. Where compiled, the weighting scheme must be documented (see Step 2 of the worked example).

Step 4: Compile fish stock asset accounts

¶1 **Action:** Record opening stock, natural growth, catch, mortality, and closing stock for commercially important pelagic species.

¶2 **Data requirements:**

- ¶3 RFMO stock assessment reports providing biomass estimates, recruitment, natural mortality, fishing mortality
- ¶4 National catch statistics by species, distinguishing **landings** and **discards**
- ¶5 VMS data for catch location (to attribute shared stocks)

¶6 **Data note on discards.** Discard estimates for highly migratory pelagic species should be drawn from RFMO observer programme data where available. For the Western and Central Pacific, the WCPFC Regional Observer Programme is the recommended primary source: it places trained independent observers on fishing vessels with mandated coverage of 100% for purse-seine vessels (since 2010) and 5% for longline vessels (since 2012). Actual coverage rates vary by fleet and year and must be documented in account metadata. Where RFMO observer data are unavailable or coverage is insufficient, compilers may use FAO global discard estimates as a fallback.⁴¹

¶7 **Calculation:**

- ¶8 Opening stock from most recent stock assessment (flag “model-projected” if the assessment predates the accounting year, and see Section 3.3 for the temporal-mismatch protocol)
- ¶9 Natural growth = recruitment + somatic growth (from stock assessment model)
- ¶10 Extraction = gross catch (landings + discards) attributed to national fleet
- ¶11 Natural mortality from stock assessment parameter M applied to population size
- ¶12 Closing stock = opening stock + growth – extraction – natural mortality

¶13 **Output:** Physical fish stock asset account with entries in tonnes, distinguishing EEZ and high seas components for migratory species, and reporting landings and discards on separate rows.

Step 5: Estimate ecosystem service flows

¶1 **Action:** Quantify the annual supply of ecosystem services from pelagic ecosystems.

¶2 **Data requirements:**

- ¶3 Primary productivity estimates from satellite ocean colour and biogeochemical models
- ¶4 Export production rates from sediment trap data or models
- ¶5 Fish catch data and resource rent estimates for fisheries provisioning services

¶6 **Calculation:**

- ¶7 Carbon sequestration (t CO₂/yr) = NPP (t C/yr) x export ratio x sequestration efficiency x 44/12
- ¶8 Fisheries provisioning service (physical) = sustainable yield (from stock assessment)
- ¶9 Fisheries provisioning service (monetary) = sustainable yield x resource rent per tonne

¶10 **Output:** Ecosystem service supply table (physical and monetary) by service type and ecosystem type.

Step 6: Value ecosystem assets (optional)

¶1 **Action:** Estimate the monetary value of pelagic ecosystem assets as the NPV of expected future service flows.

¶2 **Data requirements:**

- ¶3 Annual ecosystem service values from Step 5
- ¶4 Discount rate (4% real is commonly applied)
- ¶5 Assumptions about service flow duration and projection horizon

¶6 **Calculation:**

- ¶7 Asset value = Annual service value x PV annuity factor (r, n), where n is the projection horizon and r is the real discount rate
- ¶8 A finite 25-year horizon is recommended as the default, as RFMO stock assessment projections and SEEA EA practice for ecosystem services with substantial methodological uncertainty typically use a horizon comparable to the stock assessment projection period rather than perpetuity. Compilers adopting a perpetual annuity (Asset value = Annual service value / r) should document the assumption explicitly and apply it consistently
- ¶9 Apply to carbon sequestration and fisheries services separately
- ¶10 Document uncertainties and sensitivity to discount rate and horizon

¶11 **Output:** Monetary ecosystem asset account showing opening value, changes (enhancement, degradation), and closing value.

Worked Example

¶1 This worked example demonstrates the compilation of pelagic and open ocean ecosystem accounts for a hypothetical Pacific small island developing state (SIDS), following the extent-condition-services-valuation sequence in Sections 3.1–3.5. Given the Emerging status of this Circular, compilers should treat the methods and values below as indicative rather than prescriptive.

¶2 **Setting:** A Pacific SIDS with an EEZ of 500,000 km², predominantly comprising epipelagic waters (M2.1) over a deep ocean basin. The nation's economy depends heavily on tuna fisheries managed through the Western and Central Pacific Fisheries Commission (WCPFC). The EEZ intersects the warm pool region of the western Pacific, with seasonal upwelling along its southern boundary.

¶3 **Step 1: Extent account (year t to t+1)**

Accounting entry	M2.1 Epipelagic (km ³)	M2.2 Mesopelagic (km ³)	Total (km ³)
Opening extent	100,000	400,000	500,000

Accounting entry	M2.1 Epipelagic (km ³)	M2.2 Mesopelagic (km ³)	Total (km ³)
– Water mass boundary shifts (warming-driven)	-500	+500	0
– Thermocline depth change (reclassification)	+200	-200	0
Net change	-300	+300	0
Closing extent	99,700	400,300	500,000

¶4 The thermocline depth change is a reclassification (no net volume change, per SEEA EA para 6.14). The water mass shift is a natural reduction in epipelagic with a corresponding natural expansion in mesopelagic.

¶5 Step 2: Condition account

¶6 Condition indicators are derived from satellite oceanography, Argo float data, and RFMO stock assessments. Reference levels are based on 1990–2010 climatological means. The four indicators are presented separately rather than aggregated, consistent with **TG-2.1 Biophysical Indicators** on indicator selection and weighting.

Condition variable	Observed value	VH (reference good)	VL (degraded)	Indicator score
Primary productivity (mg C/m ² /day)	280	350	150	0.65
Dissolved oxygen at 200m (ml/L)	3.8	4.5	2.0	0.72
Tuna stock biomass (% of unfished)	42%	60%	20%	0.55
SST anomaly, transformed (-1 x C above 1990–2010 mean)	-0.8	0.0	-2.0	0.60

¶7 Worked cell – SST anomaly normalisation:

*Raw SST anomaly = +0.8 C above the 1990–2010 mean. As lower SST anomalies indicate better condition, the variable is transformed to $V = -0.8$. With $VH = 0.0$ (reference good, no anomaly) and $VL = -2.0$ (degraded, +2 C anomaly transformed), applying the standard normalisation formula (see **TG-2.1** §3.4.1):*

$$\text{Indicator} = (V - VL) / (VH - VL) = (-0.8 - (-2.0)) / (0.0 - (-2.0)) = 1.2 / 2.0 = 0.60$$

¶8 Composite index (optional): An equal-weighted arithmetic mean of the four indicators yields $(0.65 + 0.72 + 0.55 + 0.60) / 4 = 0.63$. Compilers should consider alternative weightings (e.g., management-relevance weights placing greater weight on the tuna stock variable for a fisheries-dependent SIDS) and report sensitivity to weighting choices. See SEEA EA para 5.72–5.76 and **TG-2.1 Biophysical Indicators**.

¶9 Step 3: Ecosystem services (annual flows)

¶10 The carbon sequestration physical rate of 4.5 t CO₂/km²/yr applied below is derived from biological-pump parameters as follows:

Parameter	Value	Source
Net primary production (NPP)	280 mg C/m ² /day x 365 days = 102.2 g C/m ² /yr = 102.2 t C/km ² /yr	Satellite ocean colour mean for the EEZ (matches Step 2 observed productivity)
Export ratio (e-ratio, fraction of NPP exported below mixed layer)	0.12	Henson et al. (2011), open-ocean global mean for the biological carbon pump

Parameter	Value	Source
Sequestration efficiency (fraction of exported flux reaching long-term storage depths > 1,000 m)	0.10	Siegel et al. (2014), <i>Global Biogeochemical Cycles</i> , on mesopelagic transfer efficiency in the open ocean
Derived rate	4.5 t CO₂/km²/yr	$102.2 \times 0.12 \times 0.10 \times 3.667 = 4.50 \text{ t CO}_2/\text{km}^2/\text{yr}$ ($\times 44/12$ to convert C to CO ₂ -equivalent)

¶11 Total carbon sequestration over the EEZ: $500,000 \text{ km}^2 \times 4.5 \text{ t CO}_2/\text{km}^2/\text{yr} = 2,250,000 \text{ t CO}_2/\text{yr}$.

Service	Physical quantity	Monetary value (USD)
Fisheries (tuna – national quota allocation)	45,000 tonnes	54,000,000 (resource rent)
Carbon sequestration (biological pump within EEZ)	2,250,000 t CO ₂ /yr (at 4.5 t CO ₂ /km ² /yr)	Range: 45,000,000 (low) – 114,750,000 (central) – 303,750,000 (high)
Climate regulation (ocean heat uptake)	(not separately valued)	–
Genetic resources	(qualitative – emerging)	–
Total valued services (central)		168,750,000

¶12 Carbon price range applied: (1) USD 20/t CO₂ (low, marginal abatement cost reference), (2) USD 51/t CO₂ (central, US IWG 2021 Social Cost of Carbon, 3% discount rate, 2020 USD), and (3) USD 135/t CO₂ (high, IPCC AR6 WG3 lower bound of the 1.5 C-compatible carbon price range for 2030). Compilers should present sensitivity analysis across the full range and check for updates to the US IWG SCC at the time of compilation. See **TG-1.9 Valuation** for carbon price selection.

¶13 Note: The tuna fisheries value reflects only the national quota allocation managed through WCPFC. Licence fees paid by distant-water fishing nations (approximately USD 30,000,000/yr for this hypothetical SIDS) are recorded as economic flows in the national accounts (SNA current account) and are not added to the ecosystem service supply value – the conceptual basis is described in the Section 3.5 mapping table.

¶14 Step 4: Asset valuation

¶15 Applying a 4% real social discount rate over a 25-year projection horizon (basis: a horizon broadly comparable to the RFMO stock assessment projection period, and compilers electing a perpetual annuity should substitute $1/r = 25.0$ and document the change):

Asset value (central carbon price) = $168,750,000 \times \text{PV annuity factor}(4\%, 25) = 168,750,000 \times 15.62 = \text{approximately USD } 2,635,875,000$

¶16 Sensitivity to carbon price (annual service value x 15.62 PV annuity factor):

- ¶17 Low (USD 20/t CO₂): annual services 99,000,000 -> asset value approximately USD 1,546,380,000
- ¶18 Central (USD 51/t CO₂): annual services 168,750,000 -> asset value approximately USD 2,635,875,000
- ¶19 High (USD 135/t CO₂): annual services 357,750,000 -> asset value approximately USD 5,588,055,000
- ¶20 Fisheries only (excluding carbon): annual services 54,000,000 -> asset value approximately USD 843,480,000

¶21 The wide range illustrates the dominant role of the carbon price in pelagic ecosystem asset valuation. Compilers adopting a perpetual annuity at 4% would multiply annual service values by 25.0 instead of 15.62. The choice should be documented and applied consistently.

¶22 This worked example illustrates the full accounting sequence for pelagic ecosystems. Actual compilations will require nationally specific oceanographic data, RFMO stock assessments, and careful consideration of how transboundary services are attributed. The treatment of carbon sequestration in pelagic accounts remains an active area of methodological development.

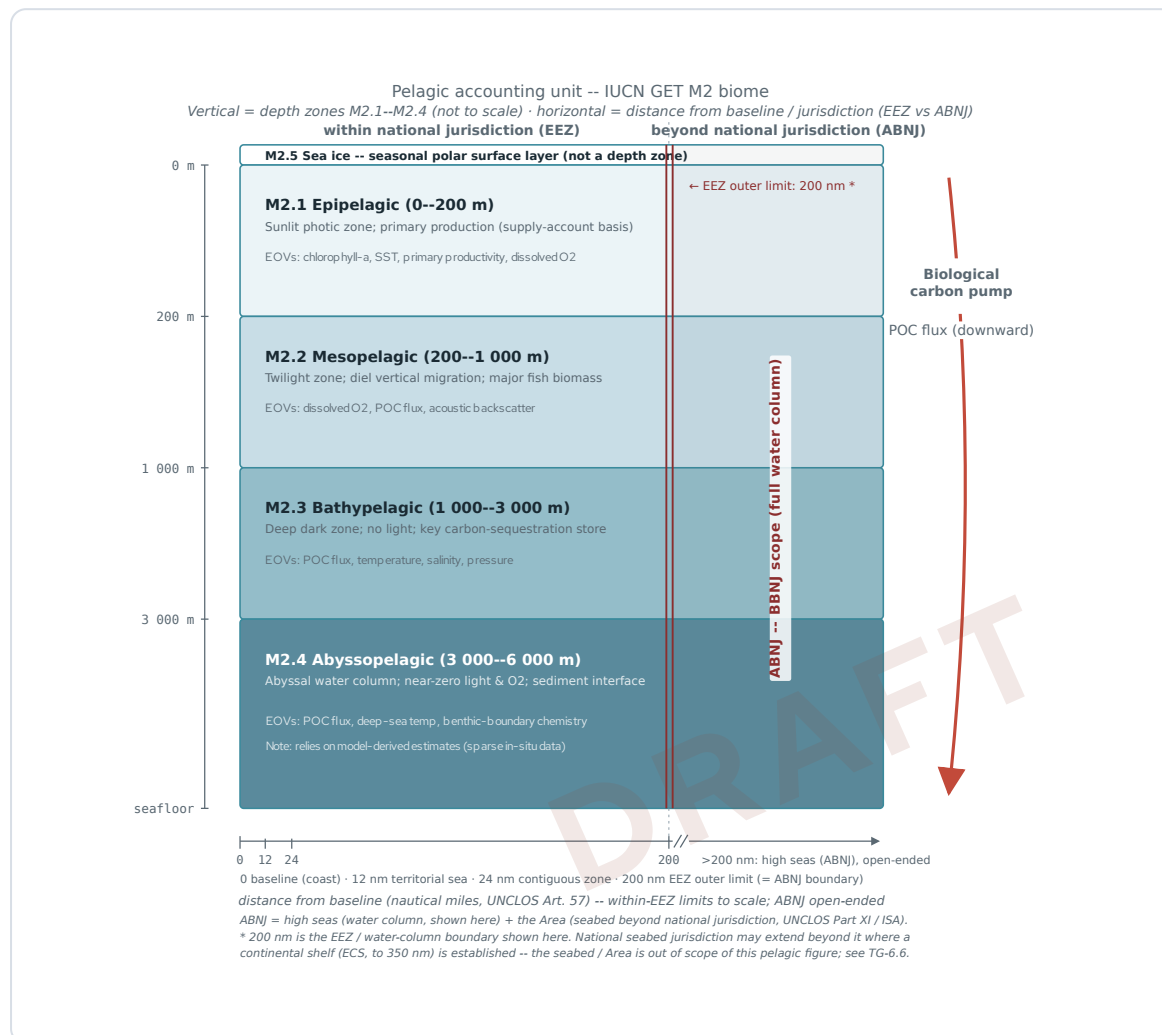


Figure 6.5.1 Vertical cross-section of four IUCN GET M2 pelagic depth zones as accounting units, crossed by the EEZ/ABNJ water-column boundary. M2.5 sea ice is a hatched surface band, not a depth zone. Depths: 200 m, 1 000 m, 3 000 m. Seabed/Area out of scope (TG-6.6).

Source: TG-6.5 (Pelagic Zone Ecosystem Accounts), Sections 2--3; IUCN Global Ecosystem Typology v2.1, M2 biome (Keith et al. 2022); SEEA CF 2012, Chapter 5 (ecosystem asset classification); BBNJ Agreement (adopted 19 June 2023; entered into force 17 January 2026), Art. 1 (area definitions).

Adapted from: IUCN GET v2.1 M2 biome schematic, with GOAP extensions: SEEA CF asset-account framing, EEZ/ABNJ jurisdictional divide, EOv annotation, biological carbon pump overlay, and depth-luminance fill encoding.

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

FOOTNOTES

1. ¶1 This Circular carries the “Emerging” badge, indicating that accounting methodologies are less developed and uncertainties remain. Approaches should be considered provisional pending further international consensus.
2. ¶2 UNCLOS, Article 136. “The Area and its resources are the common heritage of mankind.”
3. ¶3 Under the Paris Agreement, countries may include ocean-based climate mitigation measures in their nationally determined contributions (NDCs). Pelagic carbon sequestration quantification supports NDC formulation and tracking.
4. ¶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), adopted 19 June 2023. Entry-into-force date and implementation status are stated in Section 3.1.
5. ¶5 IUCN GET, M2 Pelagic ocean waters biome. “The Pelagic ocean biome is the largest on earth, comprising the open-ocean water column across all latitudes.”
6. ¶6 IUCN GET, M2 Pelagic ocean waters biome classification.
7. ¶7 IUCN GET, M2.1 Epipelagic ocean waters.
8. ¶8 IUCN GET, M2.1 Distribution.
9. ¶9 IUCN GET, M2.2 Mesopelagic ocean waters. “The diverse organisms within this layer consume and reprocess allochthonous organic material sinking from the upper, photosynthetic layer.”
10. ¶10 IUCN GET, M2.2 Distribution.
1. ¶11 IUCN GET, M2.3 Bathypelagic ocean waters. “Total biomass declines exponentially from an average of 1.45 mg.C.m⁻³ at 1,000 m deep to 0.16 mg.C.m⁻³ at 3,000 m.”
2. ¶12 IUCN GET, M2.4 Abyssopelagic ocean waters. “Due to extreme conditions and limited resources, biodiversity is very low.”
3. ¶13 IUCN GET, M2.5 Sea ice. “The seasonally frozen surface of polar oceans... is one of the most dynamic ecosystems on earth.”
4. ¶14 IUCN GET, M2.1. “Autochthonous productivity in the epipelagic layer, largely by diatoms, accounts for around half of all global carbon fixation.”
5. ¶15 SEEA EA, para 3.1l.
6. ¶16 Longhurst, A.R. (2007). *Ecological Geography of the Sea*. Academic Press. Longhurst provinces are widely used biogeographic units for pelagic ecosystems.
7. ¶17 IUCN GET, M1.9. “The most productive upwelling zones are coastal, notably in four major eastern-boundary current systems (the Canary, Benguela, California and Humboldt).”
8. ¶18 UNCLOS, Parts II, V, VII.
9. ¶19 UNCLOS, Article 56(1)(a).
10. ¶20 UNCLOS, Article 87. “The high seas are open to all States, whether coastal or land-locked.”
1. ¶21 SEEA CF, para 5.396-5.398 (EEZ asset boundary for aquatic resources). Para 5.395 concerns resource rents and fees and is cited separately in Section 3.5.
2. ¶22 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; see Section 3.1 for entry-into-force date and accounting implications.
3. ¶23 SEEA CF, para 5.399.
4. ¶24 Alarcon Blazquez, M.G., van der Veeren, R., Gacutan, J. and James, P.A.S. (2023). ‘Compiling preliminary SEEA Ecosystem Accounts for the OSPAR regional sea: experimental findings and lessons learned’. *One Ecosystem*, 8, e108030. doi:10.3897/oneeco.8.e108030. The accounts cover the OSPAR maritime area (over 13.5 million km² of the North-East Atlantic, including areas beyond national jurisdiction in the Wider Atlantic and Arctic Waters) and are, to the authors’ knowledge, the first SEEA EA compilation for a regional sea.
5. ¶25 SEEA EA, para 5.32 and Table 5.1, on ecosystem condition characteristic classes.
6. ¶26 FDES 2013, Topic 1.3.3 on marine water quality indicators including chlorophyll-a.
7. ¶27 IUCN GET, M2.1 Epipelagic ocean waters, Ecological Traits.
8. ¶28 IUCN GET, M2.2. Mesopelagic fish biomass estimates remain uncertain.
9. ¶29 UNCLOS, Article 64(1).
10. ¶30 UNCLOS, Annex I Highly Migratory Species.
1. ¶31 UN Fish Stocks Agreement (1995). Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. Treaty Series, vol. 2167, No. 37924.
2. ¶32 SEEA CF, para 5.398.
3. ¶33 SEEA CF, para 5.399.
4. ¶34 UNCLOS, Article 65.
5. ¶35 SEEA AFF, Table 3.10 aquatic products classification.
6. ¶36 BBNJ Agreement (2023), Part II (Marine genetic resources) establishes benefit-sharing provisions.
7. ¶37 The biological pump refers to the suite of biologically mediated processes that transport carbon from the surface to the deep ocean, including sinking particles, vertical migration, and physical mixing.
8. ¶38 IUCN GET, M2.2 Mesopelagic ocean waters.
9. ¶39 SEEA Biophysical Guidelines, para 308.

0. ¶40 See TG-4.1 Remote Sensing Data for detailed guidance on satellite data applications in ocean accounting.
1. ¶41 Sources: WCPFC Regional Observer Programme, Western and Central Pacific Fisheries Commission (<https://www.wcpfc.int/regional-observer-programme> (<https://www.wcpfc.int/regional-observer-programme>)); Perez Roda, M.A. et al. (2019), *A third assessment of global marine fisheries discards*, FAO Fisheries and Aquaculture Technical Paper No. 633, FAO, Rome (ISBN 978-92-5-131869-9); Kelleher, K. (2005), *Discards in the world's marine fisheries: An update*, FAO Fisheries Technical Paper No. 470, FAO, Rome. FAO global discards 2010-2014 are estimated at 9.1 million tonnes (95% CI: 6.7-16.1 million tonnes), with pelagic longline fisheries averaging a 6.7% discard rate.

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