

Spatial Data Frameworks

Helps compilers establish the spatial data foundations required for ocean accounting.

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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.

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/>

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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.

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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

- ¶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.

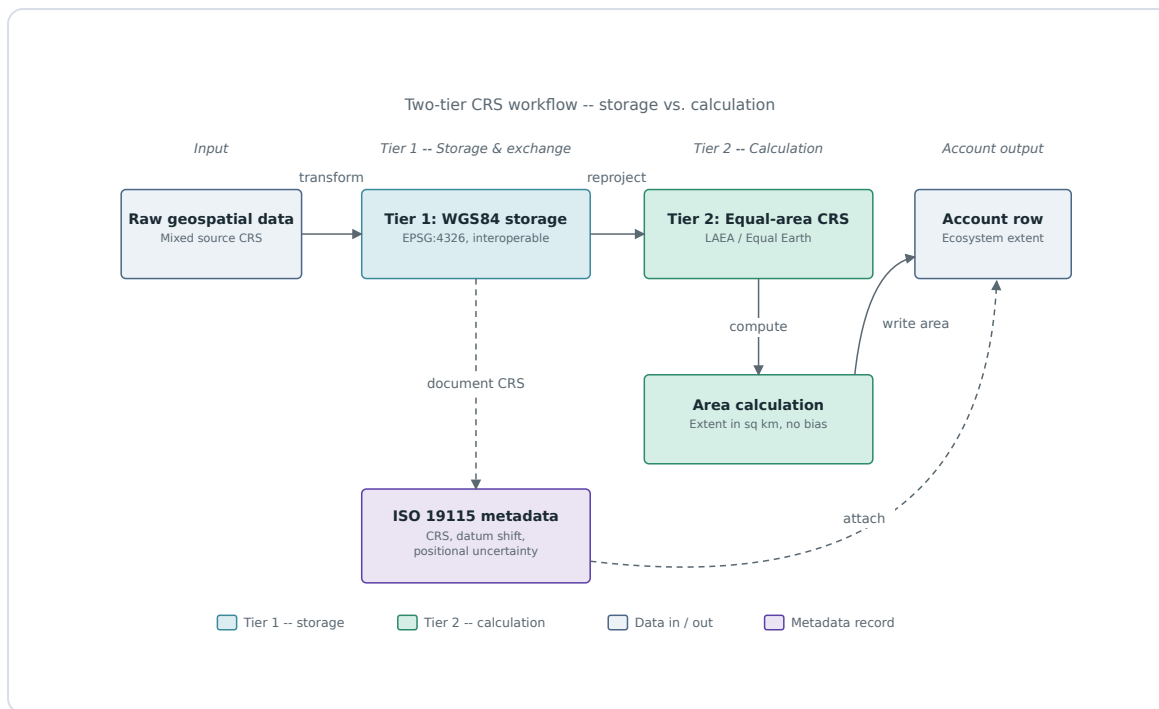


Figure 2.12.1 A two-tier CRS workflow stores data in WGS84 and reprojects to equal-area only for area calculations. Tier 1 = EPSG:4326; Tier 2 = equal-area (e.g. EPSG:8857). ISO 19115 metadata travels with each dataset.

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.

¶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

¶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 trans-boundary 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.

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 trans-boundary 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 km ²	25 km ² 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

¶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 km ²	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.

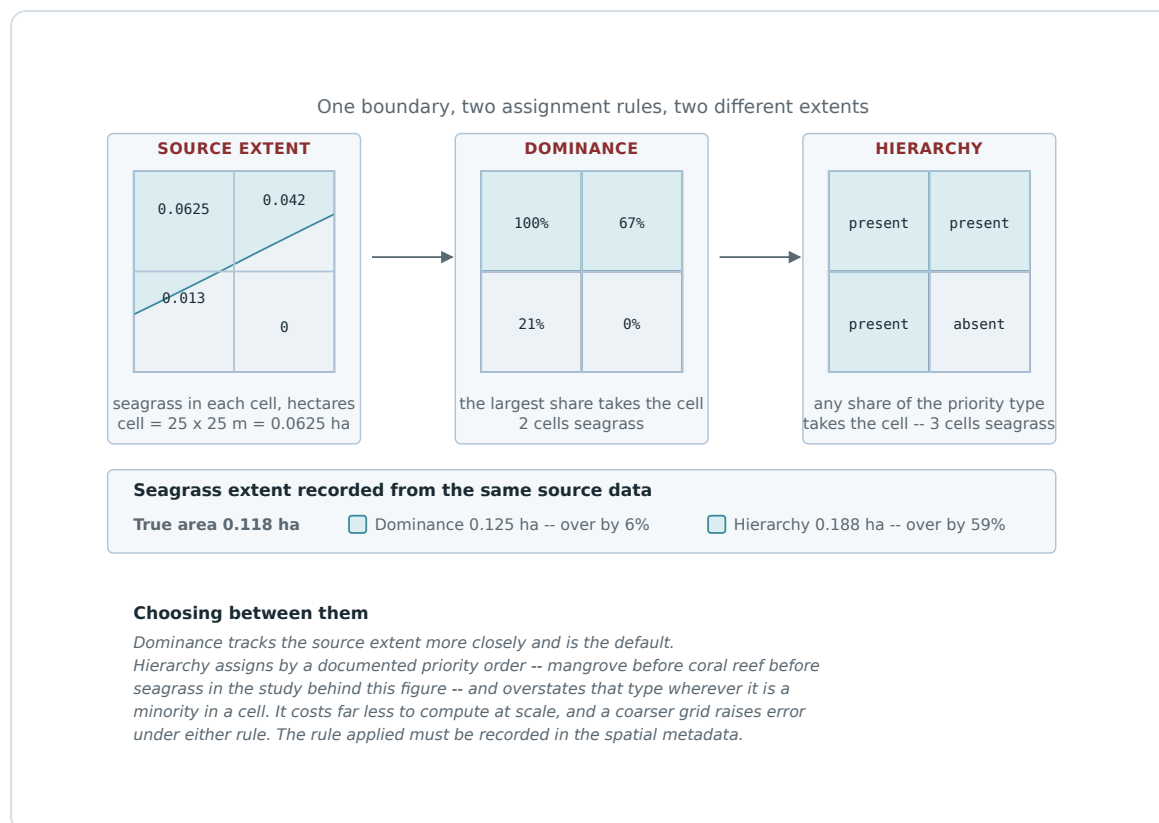


Figure 2.12.2 Where a cell is only part-covered, the assignment rule decides its type -- and the two rules return different extents from identical data.

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.

¶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.

¶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

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

¶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.

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) re-sampled 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](https://www.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

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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).
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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.
10. ¶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.