

Biological Condition Measurement

Translates biotic field measurements and remote-sensing products into SEEA EA ecosystem condition indicators (ECT Classes B1–B3 and C1).

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OUTCOME

This Circular translates biotic field measurements and remote-sensing products into SEEA EA ecosystem condition indicators (ECT Classes B1–B3 and C1). Upon implementation, compilers will be able to (1) select bio-indicators by ecosystem type, (2) apply standardised in-situ, remote-sensing, and citizen-science protocols, (3) compile condition variable tables conforming to SEEA EA Table 5.2, and (4) apply tiered data approaches in data-poor contexts.

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ABOUT THIS CIRCULAR

RECOMMENDED CITATION

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DRAFT

*Framework position: Biotic counterpart to **TG-4.8 Physical Condition Measurement**. Feeds the ecosystem-specific accounting circulars **TG-6.1** through **TG-6.5**, and draws on **TG-4.4 Citizen Science** for community-based survey data.*

¶1 ⓘ Framework Position

¶2 **TG-4.9** sits within Section 4 (Data Methods). It owns the biotic condition variable – ECT Classes B1, B2, B3 and C1 – from indicator selection and core sets by ecosystem type, through in-situ survey protocol, taxonomic resolution, quality control and the tiered data source hierarchy, to the indicator delivered against a documented reference with its sampling error and tier flag. It does not own the composites or the account. Aggregation weights for class sub-indices and overall condition indices are set under **TG-2.1 Aggregate Biophysical Indicators of Environmental State**; the condition account is **TG-3.1 Asset Accounts** Section 3.5.2. Abiotic variables are **TG-4.8 Physical Condition Measurement**.

1. Outcome

¶1 This Circular translates biotic field measurements and remote-sensing products into SEEA EA ecosystem condition indicators (ECT Classes B1–B3 and C1). Upon implementation, compilers will be able to (1) select bio-indicators by ecosystem type, (2) apply standardised in-situ, remote-sensing, and citizen-science protocols, (3) compile condition variable tables conforming to SEEA EA Table 5.2, and (4) apply tiered data approaches in data-poor contexts.

2. Requirements

- ¶1 **TG-0.1** – SEEA EA framework.
- ¶2 **TG-0.7** – QA framework.
- ¶3 **TG-3.1** – ecosystem condition account structure (SEEA EA Table 5.2).
- ¶4 **TG-4.4** – citizen-science collection protocols. **TG-4.9** governs indicator construction from such data.
- ¶5 **TG-4.8** – canonical for reference-condition framework, indicator selection criteria, variable → indicator → index pathway, and rescaling formulas. **TG-4.8** also provides the abiotic envelope for joint attribution analysis.

3. Guidance Material

3.1 Conceptual Framework

3.1.1 Defining Biological Condition

¶1 Biological condition is the biotic state of an ecosystem (composition, abundance, biomass, diversity, functional integrity) relative to a reference condition.¹ It is a subset of biodiversity and narrower than ecological integrity – an operational, measurable construct yielding standardised indicators for national accounts.² The abiotic component (physical and chemical condition) is in **TG-4.8**.

3.1.2 SEEA EA Ecosystem Condition Typology (ECT)

¶1 The SEEA EA organises ecosystem condition variables into the Ecosystem Condition Typology (ECT), a hierarchical classification of condition characteristics.³ The ECT groups condition characteristics into three groups and six classes: Group A (abiotic), with classes A1 Physical state and A2 Chemical state; Group B (biotic), with classes B1 Compositional state, B2 Structural state and B3

Functional state; and Group C (landscape), with class C1 Landscape and seascape characteristics. Biological condition variables fall in Group B and, where they describe the biotic seascape, in class C1. Table 3.1.2.1 below summarises the ECT classes within which biological condition variables primarily fall.

ECT class	Description
ECT Class B1 – Compositional state	Species composition, taxonomic richness, and presence/absence of indicator taxa. This class records which taxa are present in the ecosystem.
ECT Class B2 – Structural state	Species abundance, biomass, population density, and size-structure metrics. This class records the number of organisms present and their physical characteristics.
ECT Class B3 – Functional state	Biotic integrity indices, productivity indicators (e.g., litterfall biomass), and trophic structure metrics. This class records biological functioning of the ecosystem.
ECT Class C1 – Landscape and seascape characteristics	Habitat patch structure, connectivity, fragmentation, and reef geomorphology, where these characteristics reflect the biotic state of the ecosystem (e.g., coral framework integrity, mangrove canopy cover).

¶2 Physical and chemical condition variables (ECT Classes A1 and A2) are addressed in [TG-4.8](#). Compilers must classify each biological indicator by its ECT class before entering it in the condition account table.

3.1.3 Reference Condition

¶1 The four-approach reference-condition framework (historical, reference site, modelled, regulatory target) and the **fixed-baseline rule for time-series accounts** apply equally to biological and physical condition. See [TG-4.8 Physical Condition Measurement](#) §3.1 for the canonical framework.⁴ Bio-specific reference sources for individual indicators are listed in §3.2.3.

3.1.4 Scope Boundaries

¶1 **Boundary with TG-4.8.** Boundary-case variables are assigned by ECT class: e.g., turbidity → TG-4.8 (Class A1), and seagrass shoot density (response to turbidity) → TG-4.9 (Class B2).

¶2 **Boundary with TG-4.4.** TG-4.4 governs citizen-science collection protocols, and TG-4.9 governs indicator construction from that data.

3.2 Biological Indicator Selection

3.2.1 Selection Criteria and Indicator Framework

¶1 The SEEA EA indicator-selection criteria (measurability, ecological relevance, sensitivity to change, data availability) and the variable → indicator → index three-level hierarchy are in [TG-4.8](#) §3.2 and apply to biological indicators without modification. Biological selection additionally weights **sensitivity to anthropogenic pressures** (overfishing, nutrient loading, temperature stress, physical disturbance, invasive species) and **interpretability** for non-specialist account users. For data-poor contexts, a simpler indicator reliably measured is preferable to a theoretically superior indicator with large sampling uncertainty. Aggregation into composite indices is addressed in [TG-3.1 Asset Accounts](#).

3.2.2 Core Indicators by Ecosystem Type

¶1 The following table specifies minimum biological condition indicators by ocean ecosystem type. Indicators are classified by ECT class, assigned a data tier (see §3.4), and linked to their standard measurement protocol.

Ecosystem type	Indicator	Variable	Unit	ECT class	Data tier	Protocol reference
Coral reef	Live coral cover	% substrate covered by living coral	%	B2	1–2	GCRM Reef C
Coral reef	Coral species richness	Number of coral species per transect	count	B1	1–2	GCRM
Coral reef	Coral bleaching extent	% of colonies bleached	%	B2	1–2	CoralM Reef C
Coral reef	Reef fish biomass	Total fish biomass per area	g/m ²	B2	1–2	UVC b transect BRUVs
Coral reef	Non-indigenous species (NIS) presence	Presence/absence or % cover	binary / %	B1	1–3	GCRM iNaturalist
Seagrass meadow	Seagrass cover	% substrate covered by seagrass	%	B2	1–2	Seagrass
Seagrass meadow	Shoot density	Shoots per unit area	shoots/m ²	B2	1–2	Seagrass
Seagrass meadow	Species diversity	Shannon diversity index (H')	dimensionless	B1	1–2	Seagrass
Mangrove	Canopy cover	% canopy closure	%	C1	1–2	National est inventory, TCI
Mangrove	Stem density	Stems per unit area	stems/ha	B2	1–2	National est inventory
Mangrove	Litterfall biomass (productivity proxy)	Dry weight litter per area per time	g/m ² /yr	B3	1–2	Plot-based litterfall traps
Kelp forest / temperate reef	Kelp canopy cover	% substrate covered by kelp canopy	%	B2	1–2	REEF survey, national reef monitoring
Kelp forest / temperate reef	Stipe density	Kelp stipes per unit area	stipes/m ²	B2	1–2	Belt transect, R survey
Kelp forest / temperate reef	Sea urchin density	Individuals per unit area (trophic state indicator)	individuals/m ²	B2	1–2	Belt transect, R survey
Pelagic / open ocean	Phytoplankton biomass (chlorophyll-a)	Concentration	µg/L	B2	1–4	MODIS Aqua, Sentinel OLCI
Pelagic / open ocean	Fish stock biomass	Exploited stock biomass	tonnes	B2	1–2	RAM L Database stock assessment
Pelagic / open ocean	Marine mammal abundance index	Survey-based abundance estimate	individuals	B2	2–3	National cetacean survey program (IWC Scientific Committee framework)

Ecosystem type	Indicator	Variable	Unit	ECT class	Data tier	Protocol reference
Soft-sediment benthos	Macro-invertebrate diversity	Shannon diversity index (H')	dimensionless	B1	1–2	MOSS benthic survey
Soft-sediment benthos	Macro-invertebrate biomass	Wet or dry weight per area	g/m ²	B2	1–2	MOSS benthic survey
Soft-sediment benthos	Biotic integrity index	AMBI or BENTIX score	score	B3	1–2	ICES V protocol
All ecosystems	Non-indigenous/invasive species (NIS)	Relative abundance or occurrence	% / occurrence	B1	1–3	National programme IUCN

¶2 NIS indicators should reference EU MSFD Descriptor D2 (Non-indigenous species) for harmonisation in European seas.⁵

¶3 Sea urchin density (kelp forest / temperate reef) is an ecosystem state-shift indicator – elevated density signals a phase shift to urchin barrens. Compilers should record it as a supplementary condition variable and flag threshold exceedance rather than rescaling it to a 0–1 indicator on the same basis as canopy cover.

¶4 **Fish stock biomass (dual-role note):** Fish stock biomass (pelagic/open ocean row) serves a dual role in the SEEA EA framework. When used to characterise the biological condition of a pelagic ecosystem unit (specifically the structural state of the fish community), it is a biological condition indicator (ECT Class B2) and belongs in the ecosystem condition account. When used to track the resource stock as an economic asset, it is a natural resource asset variable belonging in the natural resource sub-account of the asset account. NSO compilers should determine which account context applies before entering the variable, and use the same data source consistently between both accounts where the variable appears in both. Cross-reference [TG-6.5 Pelagic and Open Ocean Accounting](#) for the stock account treatment.

3.2.3 Reference Condition Values

¶1 For each indicator, compilers must identify a reference condition value (the value expected at optimal biological condition) before rescaling. Reference condition values should be derived using the hierarchy described in §3.1.3. Where an empirical reference is unavailable, the approach used and its limitations should be explicitly documented in the metadata. Global products that may assist in setting reference values include:

- ¶2 ReefBase historical coral cover data for coral reef reference conditions
- ¶3 Global Mangrove Watch for mangrove canopy reference values
- ¶4 CMEMS ocean colour climatologies for phytoplankton biomass baselines
- ¶5 OBIS species occurrence archives for pre-impact species richness estimates

¶6 OBIS historical records carry geographic and taxonomic coverage bias. Compilers should assess record density for the accounting unit and supplement with regional literature or expert elicitation where coverage is sparse.

3.3 Measurement Protocols

3.3.1 In-Situ Survey Methods

¶1 **Transect surveys** are the primary method of in-situ biological condition monitoring. Three configurations are standard in ocean environments, summarised in Table 3.3.1.1 below.

Configuration	Description
Belt transects (50 m × 4 m or similar)	Used primarily for counting and measuring reef fish (for fish biomass) and mobile macroinvertebrates. Standard protocol: GCRMN fish survey module. ⁶
Line-intercept transects (50 m)	Used for benthic composition, principally live coral cover, dead coral, and other substrate categories. Standard protocol: GCRMN benthic module.
Point-contact method (quadrat or video transect)	50 points or more per quadrat; records benthic composition at each point. Used for seagrass cover (SeagrassNet protocol ⁷) and soft-sediment benthos.

¶2 Surveys should be replicated (minimum three transects per habitat stratum per site) and sites georeferenced to WGS84 with at least ±10 m accuracy. Survey data should record observer, time, depth, visibility, and sea state as ancillary variables.

¶3 **BRUVS (Baited Remote Underwater Video Systems):** BRUVS provide standardised, non-destructive estimates of reef fish abundance (MaxN metric – the maximum number of individuals of a species visible simultaneously in a frame) and can be deployed in depths and locations inaccessible to diver surveys. BRUVS data are increasingly accepted as Tier 1 data for fish biomass accounts. Compilers should report MaxN per deployment with standard uncertainty metrics. Where BRUVS and UVC transect data are both available, calibration relationships should be developed to enable time-series comparability.

¶4 **Acoustic methods:** Hydroacoustic biomass surveys (scientific echosounders, 38–200 kHz) are the standard for pelagic fish and zooplankton biomass in open-water environments. Passive acoustic monitoring (PAM) using hydrophone arrays provides abundance and distribution indices for cetaceans and acoustic soundscape indicators. Both methods require specialised expertise. NSOs should explore partnership with fisheries research agencies that operate acoustic survey vessels.

¶5 **eDNA methods:** Environmental DNA (eDNA) sampling provides species detection and community characterisation without physical capture of organisms. Two analytical workflows serve different purposes in biological condition accounts:

- ¶6 **eDNA metabarcoding** (12S rRNA for fish; 16S rRNA for bacteria/archaea; CO1 for invertebrates): identifies the species present in a water sample through sequencing. Metabarcoding provides species detection (presence/absence) and species richness or diversity indices (ECT Class B1). Sequence read counts from metabarcoding are used as occupancy proxies but are not reliable relative abundance metrics without careful calibration – read-count ratios are affected by primer efficiency, extraction yield, and PCR amplification bias. Compilers should not report metabarcoding read counts as abundance without explicit calibration evidence.
- ¶7 **Quantitative eDNA (qPCR or ddPCR with species-specific primers):** provides species-specific eDNA concentration in water, which can correlate with biomass or abundance for target species (ECT Class B2) where calibration studies are available. This workflow requires species-specific primer development and a separate analytical pipeline from metabarcoding.

¶8 Sampling protocols for both approaches should follow OBIS eDNA guidelines.⁸ Critical quality controls include: field blank samples (contamination check), positive controls (known-species spike), replication (minimum three water samples per site), and preservation in ethanol or CTAB buffer with controlled-temperature shipping. eDNA data should be deposited in OBIS or GBIF to facilitate cross-account comparison.

3.3.2 Taxonomic Resolution and Invasive Species

¶1 Biological condition surveys should aim for species-level identification wherever feasible. Where species identification is impractical in the field (e.g., cryptic polychaete taxa, small crustaceans), genus or family-level identification is acceptable, provided this is consistent across time-series

measurements and documented in the metadata. Morphospecies categories (e.g., “encrusting coral morphospecies A”) may be used where expertise is limited, but should be flagged as a data quality limitation.

¶12 Non-indigenous species (NIS) should be recorded as a dedicated condition indicator. NIS presence/absence (or relative abundance) is a SEEA EA-recognised biotic pressure indicator and corresponds to EU MSFD Descriptor D2.⁵ Where a national NIS database exists, cross-reference occurrence records to validate field identifications. NIS data should also be reported to OBIS where feasible.

3.3.3 Remote Sensing Contributions

¶1 Remote sensing provides spatial coverage for biological condition monitoring that is not achievable with in-situ surveys alone. Key remote sensing products for biological condition include:

- ¶2 **Seagrass and mangrove extent:** Sentinel-2 multispectral imagery (10 m resolution) can map seagrass and mangrove canopy cover with appropriate water column correction and training data. Global Mangrove Watch (JAXA ALOS-2 SAR) provides national mangrove area and canopy cover baselines. Cross-reference [TG-4.1 Remote Sensing and Geospatial Data](#) for processing guidance.
- ¶3 **Phytoplankton biomass:** Ocean colour sensors (MODIS Aqua, Sentinel-3 OLCI) provide chlorophyll-a concentration as a proxy for phytoplankton biomass. Monthly composites at 1–4 km resolution are available globally, and regional 300 m resolution products are available for coastal areas. Chlorophyll-a data should be validated against in-situ fluorometry or water samples where feasible.
- ¶4 **Coral reef bleaching and thermal stress:** NOAA Coral Reef Watch Degree Heating Week (DHW) products provide near-real-time and archive thermal stress data that can be used to document bleaching events. Satellite-based bleaching assessment from high-resolution imagery (Planet, WorldView) is emerging as a complement to in-situ bleaching surveys.

¶5 Remote sensing products should be validated against in-situ data before use in accounts. Accuracy assessments should be documented per the QA requirements in [TG-0.7 Quality Assurance Principles](#).

3.3.4 Citizen Science Integration

¶1 Citizen science data (collected under protocols governed by [TG-4.4 Citizen Science and Community-Based Monitoring](#)) may supply biological condition variables including:

- ¶2 Reef fish species occurrence and relative abundance (Reef Life Survey,⁹ REEF Volunteer Survey)
- ¶3 Coral condition and bleaching (CoralWatch, Reef Check – trained observer tiers)
- ¶4 Species occurrence records (iNaturalist, eBird marine species)
- ¶5 eDNA water samples (community eDNA programmes)

¶6 Before integrating citizen science data into condition indicators, compilers should apply the quality control tiers defined in [TG-4.4](#) and assess whether the spatial and temporal coverage is sufficient to represent the accounting unit. Where citizen science data are aggregated with professional survey data, the data source should be recorded as a metadata field for each account row.

3.3.5 Biotic Survey SOP References

¶1 The methods above (§3.3.1–3.3.4) describe survey families. Field implementation should follow a published, standardised protocol for the ecosystem × indicator pair being measured. Compilers should cite the SOP applied in account metadata, and document any departure (sample design, gear, replication, taxonomic resolution) against the cited reference. Indicators selected per §3.2 map to the protocols below.

Ecosystem / target	Indicator	Standard protocol	Source
Coral reef benthic	Live coral cover, substrate composition	Line-intercept transect / point-contact	GCRMN Methods Manual (2nd ed., 2021); ⁶ AIMS Long-Term Monitoring Program ¹⁰
Coral reef fish	Reef fish biomass, species composition	Belt transect (50 m × 5 m) underwater visual census	GCRMN fish module; ⁶ Reef Life Survey ⁹
Coral reef invertebrates	Macroinvertebrate density	Belt transect (50 m × 2 m)	GCRMN invertebrate module; ⁶ Reef Check ¹¹
Seagrass meadow	Shoot density, cover, canopy height	Quadrat sampling (0.25 m ²) along fixed transects	SeagrassNet Manual (Short et al. 2001) ⁷
Mangrove forest	Stem density, basal area, canopy cover	Fixed-area plots (10 m × 10 m or larger)	Kauffman & Donato (2012) CIFOR mangrove protocol ¹²
Soft-sediment benthos	Macroinvertebrate diversity, biomass	Grab/core sampling with sieving (≥0.5 mm mesh)	ISO 16665:2014; ¹³ ICES benthos WG protocols

3.3.6 Quality Control Requirements

¶1 Apply the QA framework in **TG-0.7**. Bio-specific requirements:

- ¶2 **Minimum replication:** at least three transects or quadrats per habitat stratum per site, with stratified design preferred.
- ¶3 **Detection probability** reported for BRUVS (MaxN) and acoustic surveys.
- ¶4 **eDNA contamination controls:** field blank results, positive controls, and replication metadata.
- ¶5 **Observer effect:** inter-observer reliability assessed for visual survey methods.
- ¶6 **Temporal coverage:** annual preferred, biennial accepted where resourcing constrains, and a 3-year rolling average for composite indices to smooth interannual variability.

3.4 Data Requirements and Sources

3.4.1 Tiered Data Source Hierarchy

¶1 Most national statistical offices, particularly in small island developing states and lower-income coastal countries, will lack systematic in-situ biological monitoring at full national scale. A tiered data source hierarchy allows compilers to identify the best available data for each indicator and to document the quality limitations of lower tiers:

Tier	Data source type	Suitability	Quality flag
1	National monitoring programmes (government agencies, research institutes) with consistent methodology and annual coverage	Preferred; use directly	None
2	Research and academic datasets (OBIS, GBIF, Reef Life Survey database); regional survey programmes	Acceptable with QC	Document temporal/spatial gaps
3	Citizen science programmes (per TG-4.4 protocols)	Acceptable for occurrence, relative abundance	Apply TG-4.4 QC tier; flag observer bias

Tier	Data source type	Suitability	Quality flag
4	Remote sensing proxies (per TG-4.1)	Acceptable for spatial extent, phytoplankton; limited for abundance/biomass	Validate against in-situ; report accuracy
5	Expert elicitation, modelled products, global default values	Last resort; use only where Tiers 1–4 are unavailable	Flag clearly; assess sensitivity

¶2 Where Tier 4 or 5 data are used, the revision log and metadata should record this explicitly and quantify the additional uncertainty introduced.

3.4.2 Variable Data Requirements Table

Variable	Unit	Primary source	Update frequency	Data-poor alternative
Live coral cover	%	GCRMN national surveys, Reef Check	Annual	CoralNet from photo-quadrats
Reef fish biomass	g/m ²	UVC belt transects, BRUVS	Annual	RAM Legacy Stock Assessment
Coral bleaching extent	%	Reef Check bleaching survey, CoralWatch	Annual or event-driven	NOAA CRW DHW product (thermal proxy)
Seagrass cover	%	SeagrassNet, national monitoring	Annual	Sentinel-2 remote sensing (TG-4.1)
Seagrass shoot density	shoots/m ²	SeagrassNet	Annual	Seagrass cover as proxy (document relationship)
Mangrove canopy cover	%	National forest inventory	Biennial	Global Mangrove Watch (TG-4.1)
Mangrove stem density	stems/ha	National forest inventory	Biennial	Global Mangrove Watch canopy height product
Kelp canopy cover	%	National reef monitoring, REEF survey	Annual	Sentinel-2 near-infrared mapping
Chlorophyll-a (phytoplankton)	µg/L	MODIS Aqua, Sentinel-3 OLCI	Monthly composites	CMEMS biogeochemical reanalysis
Fish stock biomass (pelagic)	tonnes	National stock assessment	Annual	RAM Legacy Database v4.65
Macro-invertebrate diversity (H')	dimensionless	MOSSCO benthic surveys	Biennial	OBIS occurrence data (modelled diversity)
Marine mammal abundance index	IWC units	National survey programme	3–5 year	IWC Scientific Committee survey programmes (POWER, SOWER, or national equivalent)
NIS occurrence	presence/count	National NIS programme, OBIS	Annual	GBIF occurrence records

3.4.3 Key Institutional Data Sources

¶1 Compilers should draw on the standard global repositories and monitoring networks for marine biological condition data.¹⁴ See [TG-4.6 Data harmonisation](#) for full treatment of inter-source comparability and metadata standards.

3.5 Reporting and Integration

3.5.1 Pathway from Measurement to Delivered Indicator

¶1 The variable → indicator → index pathway, rescaling formulas, and SEEA EA Table 5.2 row format are in **TG-4.8** §3.2 and §3.5. Figure 4.9.1 traces this pathway for biological condition: each biotic ECT class (B1, B2, B3, C1) supplies measured values to a shared condition variable, the variable is ranked against the 5-tier data source hierarchy (§3.4.1), then normalised to an indicator against a documented reference. The indicator is the deliverable. The figure's later stages – aggregation into a class index, and the Table 5.2 row – are shown to place the deliverable in context; they are compiled under **TG-2.1 Aggregate Biophysical Indicators of Environmental State** and **TG-3.1 Asset Accounts** Section 3.5.2 respectively.

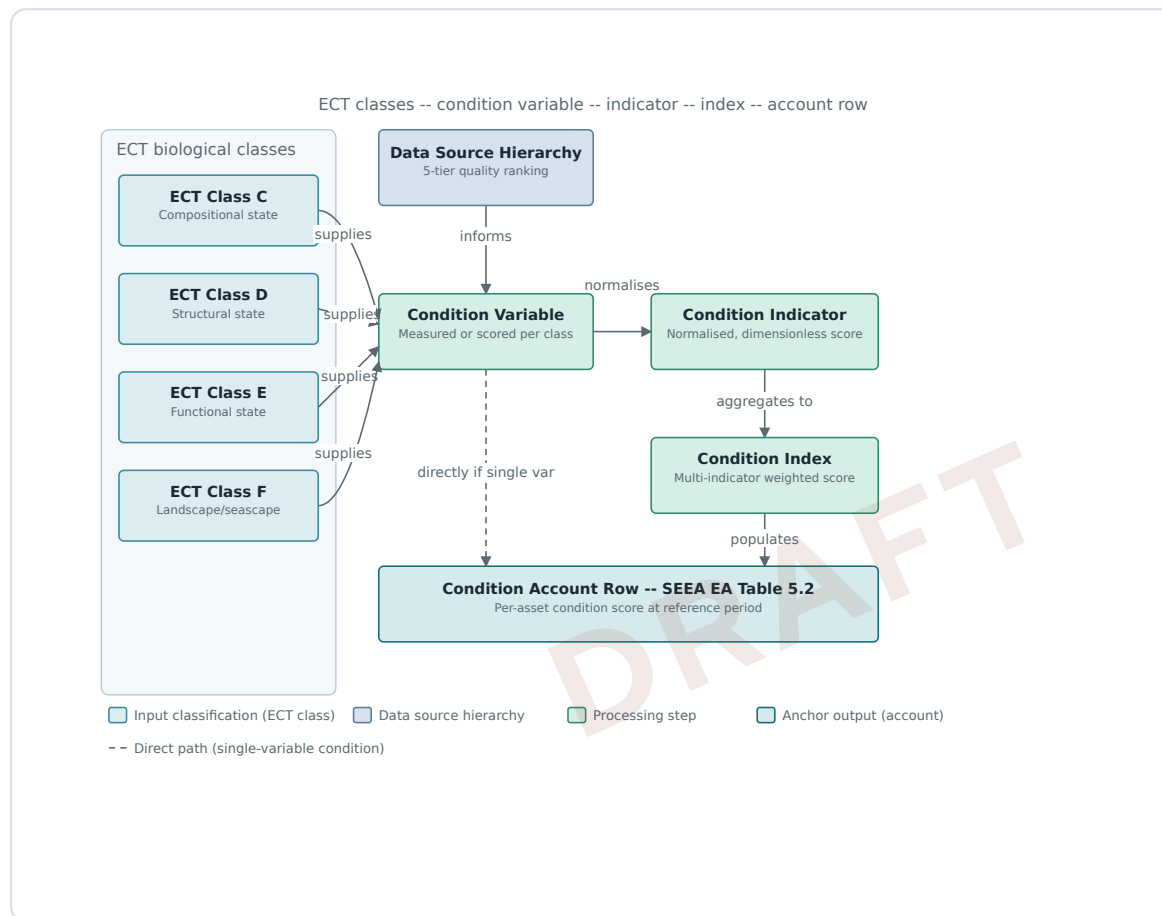


Figure 4.9.1 Four ECT biological classes feed measured values through normalisation and aggregation into a SEEA EA Table 5.2 condition-account row. Classes C--F; 5-tier hierarchy ranks data quality. A single-variable path can bypass indicator and index steps.

Source: TG-4.9, Section 4 (condition measurement pathway); SEEA EA 2024, Table 5.2 (condition variable account structure), paras. 5.30--5.32 (Ecosystem Condition Typology) and 5.60--5.68 (rescaling of condition variables to indicators and indices).

¶2 Worked bio example: live coral cover measured at 24 reef sites, mean = 28%, SE = 4%, reference year 2024. Reference (ReefBase 1990–1999 historical mean) = 55%. Indicator = $28/55 = 0.51$, SE = $4/55 = 0.07$ (the reference being fixed). That indicator, with its standard error, reference basis and data tier, is what TG-4.9 delivers. Figure 4.9.2 carries the coral-reef core indicator set (§3.2.2) through the same pathway, scoring each indicator per ECT class and then showing the downstream class sub-indices (Class B1 = 0.71, Class B2 = 0.59) and overall Coral Reef Biological Condition Index (0.65). The aggregation weights those composites require are set under **TG-2.1**, not here. Coordinate with **TG-3.1 Asset Accounts** on ECT classification before delivering, so that indicator identifiers match the account's rows.

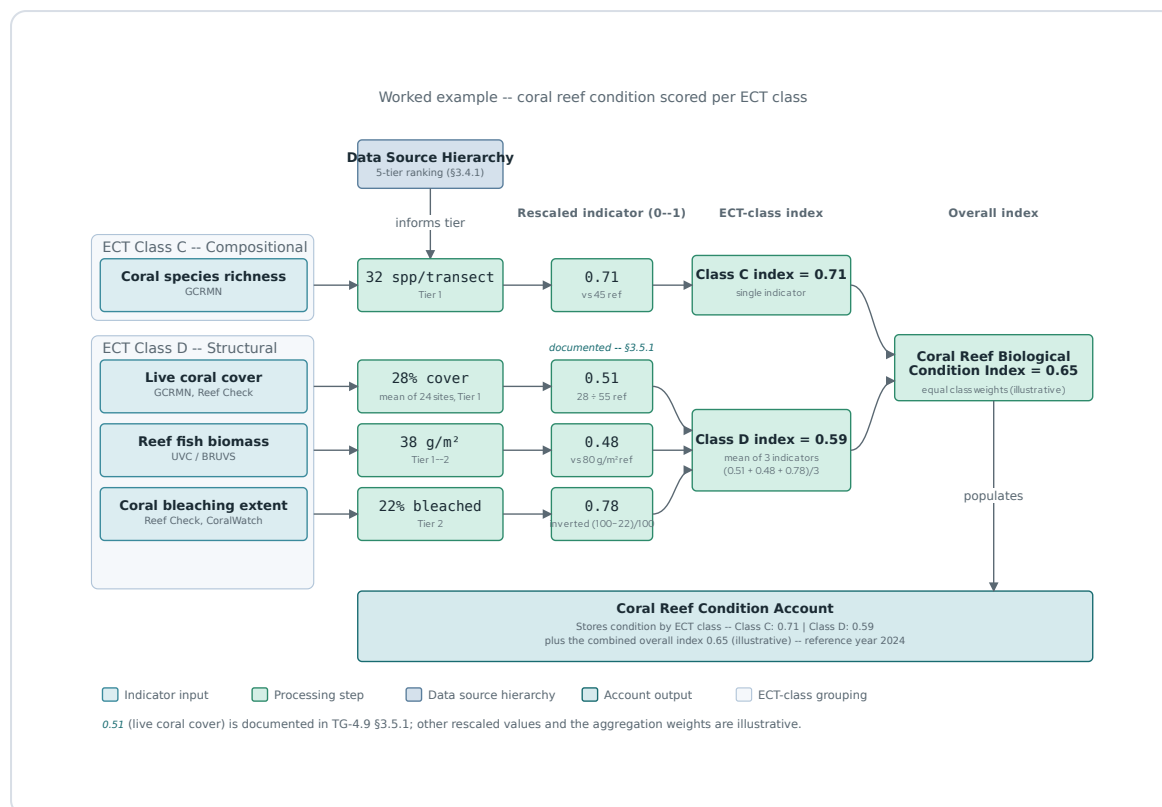


Figure 4.9.2 Coral-reef worked example scores compositional and structural indicators into class sub-indices and an overall biological condition index. Class C and D indicators aggregate per SEEA EA Table 5.2. Non-cover scores and weights are illustrative.

Source: TG-4.9 §3.2.2 (coral-reef indicator set, ECT classes, data tiers), §3.4.1 (5-tier data source hierarchy), §3.5.1 (worked live-coral-cover rescaling), §3.5.3 (account populated by ECT class); SEEA EA (2021), Table 5.2 (condition account structure) and §§5.65--5.75 (reference condition) and §§5.60--5.68 (rescaling to condition indicators). Rescaled values other than live coral cover, and the aggregation weights, are illustrative.

3.5.2 Integration with Physical Condition (TG-4.8)

¶1 Biological condition indicators should be delivered alongside physical condition variables (compiled per TG-4.8) for the same accounting period. Joint reporting enables attribution analysis: for example, a decline in coral cover (biological) co-occurring with elevated Degree Heating Weeks (physical – thermal stress) supports attribution of the biological change to bleaching pressure. Compilers should flag where biological condition indicators are likely responding to changes in physical condition variables observed in the same accounting period.

3.5.3 Handover to Condition Accounts Compilation

¶1 The biological condition indicators compiled following this Circular supply the ECT Class B1 and Class B2 rows of the ecosystem condition account, which is compiled in **TG-3.1 Asset Accounts** Section 3.5.2. Compilers using TG-3.1 should cross-reference the indicator identifiers used in this Circular's variable table (§3.4.2) with the ECT classification scheme in the account template, to ensure consistent labelling across ecosystem types and accounting periods.

3.5.4 Uncertainty Reporting

¶1 General uncertainty reporting (measurement, representativeness, model) is in **TG-4.8** §3.5 and **TG-0.7**. Bio-specific metadata additions: sampling design SE (transect/quadrat means), detection probability for BRUVS and acoustic surveys, clustering bias in citizen-science data, data-tier flag (§3.4.1), and reference-condition basis. Spatial data follow ISO 19115, and occurrence records follow Darwin Core (OBIS/GBIF).

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

5. References

1. ¶1 United Nations et al. (2021). *System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA EA)*. United Nations Statistics Division. Chapter 5, §5.1.
2. ¶2 SEEA EA (2021), §5.10. See also: Secretariat of the Convention on Biological Diversity (2020). *Global Biodiversity Outlook 5*. CBD Secretariat.
3. ¶3 SEEA EA (2021), §§5.46–5.68. The ECT is reproduced in full in Annex 5A.
4. ¶4 SEEA EA (2021), §§5.65–5.75 and Appendix A5.2 (reference-condition framework; see TG-4.8 §3.1 for the canonical write-up).
5. ¶5 European Commission (2008). Marine Strategy Framework Directive (2008/56/EC), Annex I, Descriptor D2 (Non-Indigenous Species).
6. ¶6 Global Coral Reef Monitoring Network (2021). *The Coral Reef Status Report 2020*. GCRMN. See also: GCRMN (2021). *GCRMN Methods Manual for Coral Reef Monitoring and Assessment* (2nd ed.).
7. ¶7 Short, F.T. et al. (2001). *SeagrassNet Manual for Scientific Monitoring of Seagrass Habitat*. SeagrassNet Programme.
8. ¶8 Ocean Biodiversity Information System (2024). *OBIS eDNA Guidelines: Mobilising DNA-derived biodiversity data*. OBIS. https://manual.obis.org/dna_data (https://manual.obis.org/dna_data)
9. ¶9 Edgar, G.J. & Stuart-Smith, R.D. (2014). Systematic global assessment of reef fish communities by the Reef Life Survey program. *Scientific Data*, 1, 140007.
10. ¶10 Australian Institute of Marine Science (ongoing). *Long-Term Monitoring Program: Standard Operational Procedures for Reef Surveys*. AIMS, Townsville. <https://www.aims.gov.au/research-topics/monitoring-and-discovery/monitoring-great-barrier-reef/long-term-monitoring-program> (<https://www.aims.gov.au/research-topics/monitoring-and-discovery/monitoring-great-barrier-reef/long-term-monitoring-program>)
11. ¶11 Hodgson, G. et al. (2006). *Reef Check Instruction Manual: A Guide to Reef Check Coral Reef Monitoring*. Reef Check Foundation, Pacific Palisades, CA.
12. ¶12 Kauffman, J.B. & Donato, D.C. (2012). *Protocols for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forests*. CIFOR Working Paper 86. Center for International Forestry Research, Bogor.
13. ¶13 International Organization for Standardization (2014). *ISO 16665:2014 – Water quality – Guidelines for quantitative sampling and sample processing of marine soft-bottom macrofauna*. ISO, Geneva.
14. ¶14 Key institutional data sources include OBIS (Ocean Biodiversity Information System, <https://obis.org/>), GBIF (Global Biodiversity Information Facility, <https://www.gbif.org/>), IUCN Red List (<https://www.iucnredlist.org/>), Reef Life Survey, RAM Legacy Stock Assessment Database (v4.65, <https://www.ramlegacy.org/>), GCRMN (Global Coral Reef Monitoring Network, methods manual 2021 ed.), SeagrassNet, and NOAA Coral Reef Watch (v3.1 Daily 5km, <https://coralreefwatch.noaa.gov/>) – see TG-4.6 for full treatment.