

Flows from Economy to Environment

Provides guidance on compiling accounts for flows from the economy to the marine and coastal environment.

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

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

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

OUTCOME

This Circular provides guidance on compiling accounts for flows from the economy to the marine and coastal environment, encompassing pollution, residuals, and physical pressures. Upon completing this Circular, readers will understand:

- Why tracking economy-to-environment flows matters for ocean policy and management
- How to compile physical flow accounts for emissions, waste, and residuals that reach marine waters, and the residual categories relevant to marine and coastal assessment (Section 3.2)
- How terrestrial pressures are attributed across the land-sea interface to the coastal units that receive them, using drainage basin allocation (Section 3.5)
- How to attribute land-based pollution to coastal and marine areas using drainage basin allocation
- How to measure physical pressures such as underwater noise and habitat disturbance
- How to link residual flow accounts to pressure indicators and ecosystem condition accounts

The guidance enables compilation of residual flow accounts consistent with the System of Environmental-Economic Accounting Central Framework (SEEA CF). It integrates with the broader Ocean Accounts framework described in [TG-0.1 General Introduction](#). This Circular builds on the physical flow accounting framework established in [TG-3.1 Asset Accounts](#) and the economic activity classifications detailed in [TG-3.3 Economic Activity Relevant to the Ocean](#). The accounts compiled using this guidance support derivation of indicators for environmental pressure assessment ([TG-2.7 Pollution and Other Flows to Environment](#)) and ecosystem degradation monitoring ([TG-2.8 Climate Change Indicators](#)).

CONTENTS

1. Outcome	3
2. Requirements	3
3. Guidance Material	3
3.0 Decision Use-Case Framing	4
3.1 Conceptual Framework for Residual Flows	4
3.2 Pollution and Emissions	5
3.3 Solid Waste	11
3.4 Compilation Procedure for Physical Flow Accounts	13
3.5 Attribution to Economic Sectors	16
3.6 Physical Pressures	21
3.7 Combined Presentations and Indicators	23
3.8 Cross-Stack Connections	24
3.9 Monetary Valuation of Residual Flows	25
4. Data Sources and Compilation	26
5. Acknowledgements	28
6. References	28

ABOUT THIS CIRCULAR**RECOMMENDED CITATION**

Flows from Economy to Environment (2026) (GOAP Technical Guidance on Ocean Accounting, TG-3.4, v0.9.2). GOAP Secretariat.
<https://guidance.oceanaccounts.org/circulars/section-3/3-4-flows-econ-env/>

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

DRAFT

¶1 ⓘ Framework Position

¶2 TG-3.4 provides the pressure-side complement to TG-3.2 Flows from Environment to Economy, which records the extraction of resources from the ocean. Where TG-3.2 measures what the economy takes from the marine environment, this Circular measures what the economy returns to it – pollution, residuals, and physical disturbances. Together, TG-3.2 and TG-3.4 form the two-directional boundary between economy and environment within the Section 3 physical flow accounts, and their outputs feed directly into the pressure indicators compiled in TG-2.7 Pollution and Other Flows to Environment and TG-2.8 Climate Change Indicators.

¶3 **Scope.** TG-3.4 owns the residual side of the physical supply and use table: the substance rows, the generating-industry columns, the receiving-medium columns, and the supply-equals-use identity for each substance. It cross-refers for substance-specific method to Section 6 – marine litter and plastics to **TG-6.12**, aquaculture effluent to **TG-6.8**, shipping emissions to **TG-6.10** – and for the monitoring and modelling that produce the quantities to Section 4.

1. Outcome

¶1 This Circular provides guidance on compiling accounts for flows from the economy to the marine and coastal environment, encompassing pollution, residuals, and physical pressures. Upon completing this Circular, readers will understand:

- ¶2 Why tracking economy-to-environment flows matters for ocean policy and management
- ¶3 How to compile physical flow accounts for emissions, waste, and residuals that reach marine waters, and the residual categories relevant to marine and coastal assessment (Section 3.2)
- ¶4 How terrestrial pressures are attributed across the land-sea interface to the coastal units that receive them, using drainage basin allocation (Section 3.5)
- ¶5 How to attribute land-based pollution to coastal and marine areas using drainage basin allocation
- ¶6 How to measure physical pressures such as underwater noise and habitat disturbance
- ¶7 How to link residual flow accounts to pressure indicators and ecosystem condition accounts

¶8 The guidance enables compilation of residual flow accounts consistent with the System of Environmental-Economic Accounting Central Framework (SEEA CF)¹. It integrates with the broader Ocean Accounts framework described in TG-0.1 General Introduction. This Circular builds on the physical flow accounting framework established in TG-3.1 Asset Accounts and the economic activity classifications detailed in TG-3.3 Economic Activity Relevant to the Ocean. The accounts compiled using this guidance support derivation of indicators for environmental pressure assessment (TG-2.7 Pollution and Other Flows to Environment) and ecosystem degradation monitoring (TG-2.8 Climate Change Indicators).

2. Requirements

¶1 This Circular requires familiarity with:

- ¶2 **TG-0.1 General Introduction to Ocean Accounts** – for the conceptual framework and key components of Ocean Accounts
- ¶3 **TG-3.1 Asset Accounts** – for the general framework of physical supply and use tables and residual flow accounting
- ¶4 **TG-3.3 Economic Activity Relevant to the Ocean** – for industry classifications and economic sector definitions relevant to ocean accounting

3. Guidance Material

3.0 Decision Use-Case Framing

¶1 Residual flows from the economy to the marine environment are pressures that affect ecosystem health, fisheries productivity, coastal protection capacity, and human well-being. Policy-makers require systematic information on these flows to answer questions such as:

- ¶2 Which economic sectors contribute most to nutrient loading in coastal waters, and how can agricultural and aquaculture practices be adjusted to reduce eutrophication?
- ¶3 What is the trajectory of plastic waste reaching the ocean from land-based sources, and are waste management interventions reducing marine litter?
- ¶4 How do ship emissions contribute to ocean acidification and coastal air quality, and what would be the impact of stricter fuel standards?
- ¶5 Which coastal areas face the greatest pollution pressure from multiple sources, and where should marine spatial planning prioritise environmental protection?

¶6 Ocean accounts for residual flows provide an empirical foundation for addressing these questions. Organising data on emissions, waste, and physical disturbances within a coherent accounting framework allows compilers to track pressures over time, attribute them consistently to economic sources, and integrate them with ecosystem condition accounts to assess environmental outcomes. These accounts support evidence-based policy design, monitoring of international commitments (including SDG Target 14.1 on marine pollution), and evaluation of intervention effectiveness.

3.1 Conceptual Framework for Residual Flows

¶1 The marine environment receives substantial flows of residuals from economic activity, including pollutants discharged to water, solid waste and marine litter, atmospheric emissions that deposit in ocean waters, and physical disturbances such as underwater noise and light pollution. These flows constitute pressures on marine ecosystems that can affect ecosystem condition and the capacity of marine ecosystems to deliver services. Accounting for these flows enables assessment of the environmental impact of economic activity and supports policy responses aimed at reducing pressures on the marine environment.

¶2 The accounting framework for residual flows draws on the physical supply and use table (PSUT) structure established in the SEEA Central Framework². Residuals are defined as flows of solid, liquid, and gaseous materials, and energy, that are discarded, discharged, or emitted by establishments and households through processes of production, consumption, or accumulation³. For ocean accounting purposes, the focus is on residual flows that reach marine and coastal waters either directly or through intermediary pathways.

¶3 Residual flows correspond to the 'Pressures' component in the widely used Drivers-Pressures-State-Impact-Response (DPSIR) framework for environmental assessment. Economic activities (Drivers) generate residual flows (Pressures) that affect marine ecosystem condition (State), resulting in consequences for ecosystem services and human welfare (Impact), which in turn prompt policy actions (Response). The accounting framework presented in this Circular provides a systematic, quantitative basis for measuring the Pressures component and linking it to the economic Drivers through industry attribution. Figure 3.4.1 sets the DPSIR concept alongside the physical supply-use table that records these flows. Each substance is routed in that table to its receiving destination.

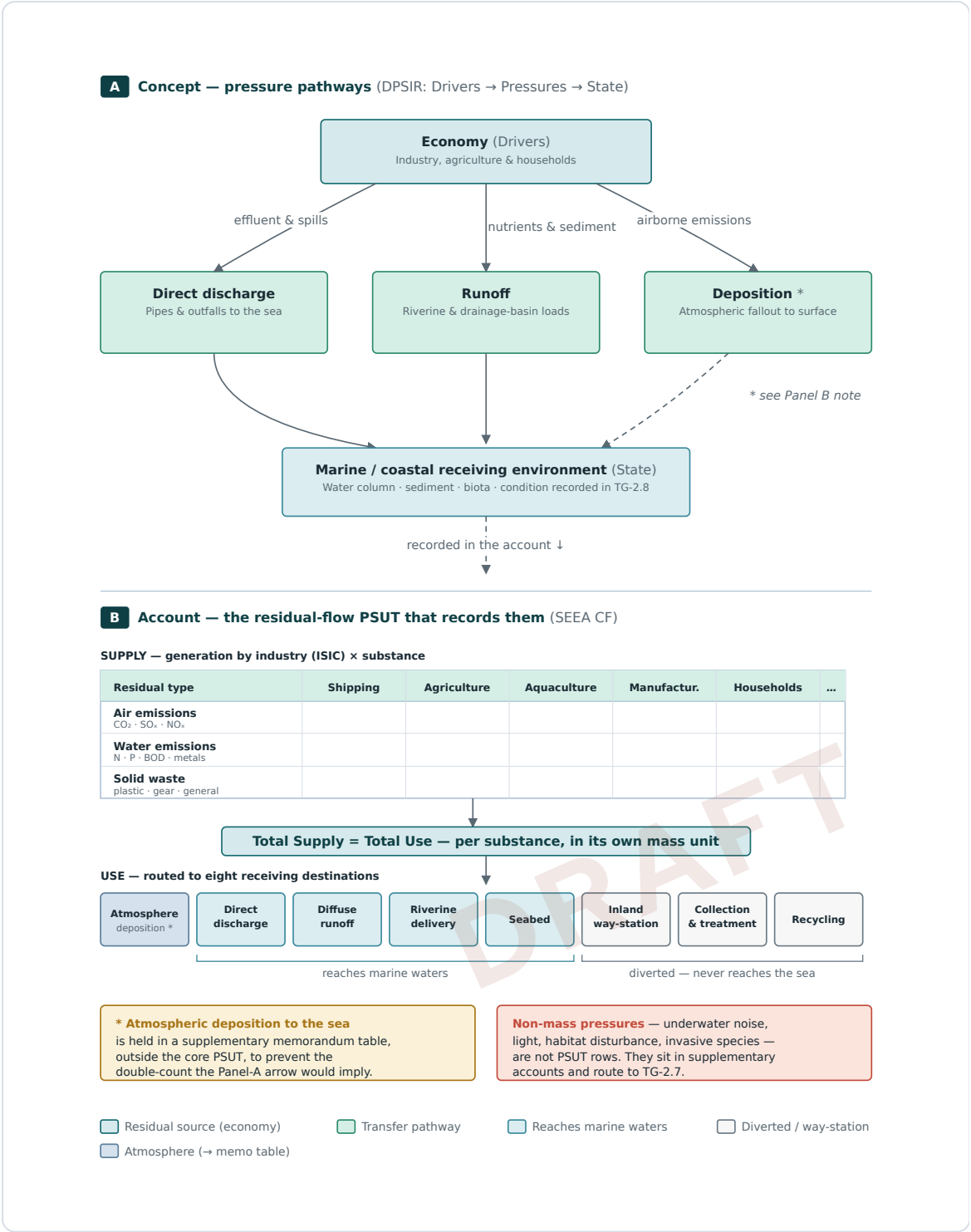


Figure 3.4.1 Residual pollution is shown as concept pathways (Panel A) and as the balancing physical supply-use table that records them (Panel B). Diverted destinations must stay on the use side to keep supply = use; atmosphere and non-mass pressures use memorandum or supplementary accounts.

Source: TG-3.4 draft §3.4 (Table 1 residual-flow PSUT template), §3.5 (attribution to industries; drainage-basin allocation), §3.6 (physical pressures); residual-flow recording per SEEA CF. Complements the carbon-cycle figure (fig-tg-3-4-carbon-cycle), which depicts the atmospheric pathway in isolation.

3.2 Pollution and Emissions

¶1 Marine pollution encompasses substances released to water resources and the atmosphere that subsequently affect ocean waters. The SEEA framework distinguishes between emissions

to air, emissions to water, and emissions to soil, each of which can contribute to marine environmental degradation⁴.

3.2.1 Emissions to water

¶1 Emissions to water are substances released to water resources by establishments and households as a result of production, consumption, and accumulation processes⁵. These emissions can reach marine waters through several pathways, summarised in Table 3.2.1 below.

Pathway	Description
Direct discharges	Substances released directly to marine or coastal waters from industrial facilities, vessels, or coastal infrastructure.
Indirect discharges via sewerage	Substances released to sewerage systems that subsequently discharge to marine waters, either treated or untreated.
Non-point source emissions	Diffuse releases including urban runoff, agricultural runoff carrying fertilisers and pesticides, and leaching from contaminated sites.

¶2 The SEEA water emissions account records the quantity of substances added to water by establishments and households during an accounting period, expressed in mass units (kilograms or tonnes depending on the substance)⁶. Table 3.2.1 below summarises key substance categories for marine water quality.

Category	Description
Nutrients	Nitrogen and phosphorus compounds that contribute to eutrophication; SDG indicator 14.1.1 specifically addresses coastal eutrophication through an index that includes nutrient loading ⁷ ; agricultural activities are a primary source, particularly through application of fertilisers and management of livestock manure, as documented in the SEEA Agriculture, Forestry and Fisheries (SEEA AFF) guidance on nutrient flow accounts ⁸ .
Organic matter	Measured through biological oxygen demand (BOD) and chemical oxygen demand (COD), indicating substances that affect oxygen balance in receiving waters.
Heavy metals	Including mercury, cadmium, lead, and other metals that accumulate in marine food chains.
Persistent organic pollutants	Chemicals that resist degradation and bioaccumulate, including legacy pollutants such as PCBs and contemporary substances of concern.
Oil and petroleum products	From operational discharges, spills, and urban runoff.
Pharmaceuticals and personal care products	Emerging contaminants of increasing concern for marine ecosystems.

¶3 Microplastics are particles less than 5mm, either fragmented from larger items or manufactured as primary microplastics (e.g., microbeads, pellets). They represent a growing concern for marine ecosystems⁹. For accounting classification, compilers should apply the following decision tree:

- ¶4 **(a) Primary microplastics** (manufactured as such, e.g., industrial pellets, cosmetic microbeads) – record as solid waste attributed to the generating industry at the point of generation. These do not appear as water emissions.
- ¶5 **(b) Secondary microplastics** (formed by in-environment fragmentation of larger plastic items) – these are out of scope for the generating-industry supply side of the account. Record them only in a supplementary note to the account. The originating plastic items will already appear as solid waste under the appropriate industry.
- ¶6 **(c) Microplastics in treated or untreated wastewater effluent** – record as water emissions attributed to the sewerage industry (ISIC 37), not to the originating consumer industry. This

follows the SEEA CF principle that residuals generated through treatment or intermediary processing are attributed to the unit carrying out that activity³.

¶7 Applying this decision tree consistently prevents double-counting between the solid waste and water emissions rows of the account. Compilers should document the classification approach adopted in account metadata, as required by SEEA CF paragraphs 3.73–3.87.

¶8 For ocean accounting, the water emissions account should be extended to distinguish between:

- ¶9 Emissions to inland water resources that subsequently flow to marine waters
- ¶10 Emissions directly to coastal and marine waters
- ¶11 Emissions collected by sewerage systems with discharge to marine waters

¶12 The SEEA Technical Note on Water Accounting provides detailed guidance on the structure of water emission accounts, including treatment of point and non-point sources¹⁰.

3.2.2 Atmospheric emissions affecting marine waters

¶1 Certain atmospheric emissions ultimately deposit in ocean waters and contribute to marine environmental change. Air emissions accounts record gaseous and particulate substances released to the atmosphere by establishments and households¹¹. Substances of particular relevance for marine impacts include:

- ¶2 **Carbon dioxide (CO₂)** – contributing to ocean acidification through absorption of atmospheric CO₂ by ocean surface waters. Ocean acidification affects calcifying organisms including corals, molluscs, and some plankton species, with implications for marine food webs and fisheries productivity
- ¶3 **Nitrogen compounds (NO_x, NH₃)** – contributing to atmospheric deposition of nitrogen to marine waters, supplementing waterborne nutrient loading
- ¶4 **Sulphur compounds (SO_x)** – contributing to atmospheric deposition and affecting marine chemistry
- ¶5 **Mercury and other metals** – depositing through wet and dry atmospheric deposition, entering marine food chains

¶6 The accounting challenge is to link atmospheric emissions to their marine deposition, which requires integration with atmospheric modelling or use of deposition coefficients. The SEEA CF notes that such atmospheric transfers occur within the environment and are generally not recorded in the air emissions account. Whilst that convention governs the core account, the atmospheric pathway from economic activity to marine impact may warrant supplementary recording for ocean accounting purposes¹².

¶7 Supplementary memorandum table for atmospheric deposition to marine waters

¶8 To provide compilers with a mechanism for recording the atmospheric deposition pathway without creating double counting in the core PSUT, a supplementary memorandum table may be compiled alongside the core account. This table is explicitly outside the SEEA CF core account structure and must not be added to or substituted for Table 1. Its purpose is to support policy analysis linking economic air emission sources to marine nitrogen and sulphur deposition.

¶9 *Table M1: Supplementary Memorandum Table – Estimated Atmospheric Deposition to Marine Waters (outside SEEA CF core account)*

Substance	Source industry (supply from core air emissions account)	Estimated deposition to EEZ/marine area (tonnes/year)	Data source for deposition estimate
Nitrogen (NO _x as N)	Shipping (ISIC 50), Agriculture (ISIC 01), Energy (ISIC 35)	[estimate]	EMEP regional deposition model; national deposition monitoring

Substance	Source industry (supply from core air emissions account)	Estimated deposition to EEZ/marine area (tonnes/year)	Data source for deposition estimate
Sulphur (SO _x as S)	Shipping (ISIC 50), Energy (ISIC 35)	[estimate]	EMEP regional deposition model
Mercury	Energy (ISIC 35), Manufacturing (ISIC 24)	[estimate]	AMAP/UNEP global atmospheric mercury deposition model

¶10 The upstream (economic) side of this table draws directly on the core air emissions account totals for the relevant industries and substances. The deposition estimates are derived from atmospheric modelling or regional datasets. For European countries, the EMEP model provides substance-specific wet and dry deposition to sea areas¹². The table should carry a clear label distinguishing it from the core PSUT so that users do not interpret the deposition column as a separate use-side entry that would generate double counting with the “Atmosphere” use column in Table 1.

¶11 Ocean acidification (the decrease in ocean pH resulting from absorption of atmospheric CO₂) is a major indirect pathway from economic residual flows to marine environmental change. The ocean absorbs approximately 25–30% of anthropogenic CO₂ emissions, with measurable effects on marine chemistry. SDG indicator 14.3.1 tracks ocean acidification using mean marine acidity (pH) measurements. For ocean accounts, the air emissions account provides the upstream measure (CO₂ generated by economic activity), whilst the ecosystem condition account records the downstream effect (changes in ocean pH).

¶12 The carbon cycle describes how carbon flows between the atmosphere, biosphere, oceans, geosphere, and the economy. Tracing the full pathway from economic emissions to marine environmental impact depends on this cycle. Figure 3.4.2 presents the main components of the carbon cycle as described in SEEA EA^{13, 14}.

DRAFT

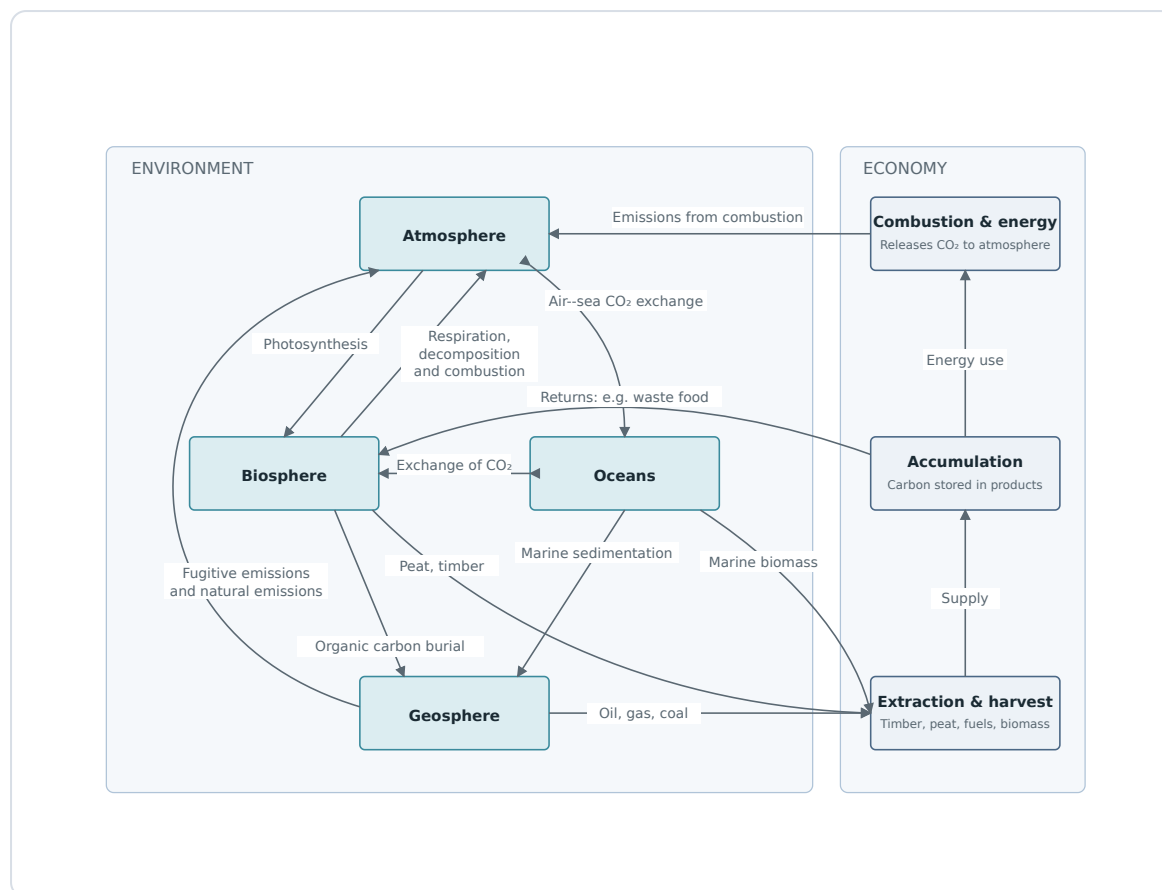


Figure 3.4.2 Global carbon stocks in atmosphere, biosphere, oceans and geosphere exchange with the economy through extraction, use and emissions. Air--sea CO₂ exchange is the dominant ocean carbon flux for ocean accounting.

Source: SEEA EA 2024, Figure 13.1; air--sea CO₂ exchange and ocean carbon flows after IPCC AR6 WG1 Chapter 5.

Adapted from: SEEA EA 2024, Figure 13.1 -- redrawn in the GOAP palette with the economy disaggregated into extraction, accumulation and combustion activities, and ocean carbon flows (air--sea exchange, marine sedimentation, marine biomass extraction) made explicit for ocean-accounting relevance.

¶13 For ocean accounting, the key pathways include: emissions from combustion of fossil fuels (geosphere → economy → atmosphere), ocean uptake of atmospheric CO₂ (atmosphere → oceans), and sequestration by coastal ecosystems such as mangroves and seagrasses (atmosphere → biosphere). The residual flow accounts described in this Circular capture the economy-to-atmosphere pathway, whilst the ecosystem service accounts in [TG-3.2 Flows from Environment to Economy](#) capture the ocean and biosphere absorption pathways.

3.2.3 Marine-specific pollution sources

¶1 Certain pollution sources are specific to marine environments:

- ¶2 **Vessel emissions** – discharges from ships including bilge water, ballast water (with associated invasive species risk), sewage, and cargo residues. The International Maritime Organization's MARPOL Convention provides regulatory framework for these discharges¹⁵. Ballast water management is also addressed under the IMO Ballast Water Management Convention (2004, entered into force 2017)
- ¶3 **Offshore operational discharges** – produced water from oil and gas extraction, drilling fluids, and platform discharges. Guidance on offshore energy accounting is provided in [TG-3.10 Offshore Energy](#)
- ¶4 **Aquaculture effluent** – nutrient-rich discharges, pharmaceutical residues, and organic matter from marine aquaculture operations. These flows should be recorded as part of aquaculture industry emissions (ISIC 0321)

- ¶5 **Port operations** – dredging spoils, stormwater runoff, and operational discharges from port facilities

¶6 **Ballast water: supplementary physical account**

¶7 Ballast water discharge can be recorded in a supplementary physical account, distinct from the core material flow account, using the following data elements:

- ¶8 **(a) Volume of ballast water discharged** in national waters (cubic metres per year), sourced from IMO port state control records or vessel self-reporting under the Ballast Water Management Convention
- ¶9 **(b) Origin port classification** – categorising ballast water by the region of intake provides a proxy indicator of the probability of non-native species introduction. Ports in different biogeographic regions carry different species assemblages, and this classification supports risk-tiered monitoring
- ¶10 **(c) BWM Convention compliance status** – expressed as the percentage of vessels discharging in national waters that meet the D-2 biological treatment standard under the IMO Ballast Water Management Convention (2004, in force 2017)

¶11 Invasive species introduced via ballast water are a categorical pressure indicator rather than a mass-flow residual and cannot be recorded within the standard PSUT rows. This pressure is flagged for treatment in [TG-2.7 Pollution and Other Flows to Environment](#). Compilers constructing the ballast water supplementary account should draw on port state control authority records and flag the account clearly as supplementary to, and not included in, Table 1 totals¹⁶.

Residual categories for marine and coastal receiving environments

¶1 *Table 3.2.9: Residual flow categories relevant to marine and coastal assessment*

Residual Category	Examples	EIA Relevance	Measurement Units
Emissions to water	Nutrients (N, P), heavy metals, POPs, thermal effluents, sediment	Direct marine water quality impacts	kg/year, mg/L concentration
Emissions to air	GHGs, particulates, NOx	Ocean acidification, climate effects	tonnes CO ₂ e/year
Solid waste	Marine debris, construction waste, dredge spoil	Benthic habitat impacts, debris accumulation	tonnes/year
Natural resource residuals	Bycatch discards, processing waste	Ecosystem function, nutrient cycling	tonnes/year

¶2 The physical supply and use table organises these flows, recording which industries generate which residuals and distinguishing residuals collected or treated from those discharged directly. Four uses follow, and they are what project-level and cumulative assessment draw on ([TG-1.6 OA and Environmental Impact Assessment](#) Section 3.4):

¶3 **Source attribution:** Identifying which economic activities contribute which residual flows to marine receiving environments. For example, physical flow accounts might record that aquaculture contributes the largest share of nitrogen loading to a coastal embayment (hypothetically 45%), followed by land-based agriculture (35%) and urban wastewater (20%), providing context for assessing a proposed expansion of aquaculture operations.

¶4 **Load estimation:** Quantifying total residual flows entering marine ecosystems from multiple sources. Accounts compiled at regional scale provide baseline pollution loading against which project incremental loads can be compared.

¶5 **Pathway tracing:** Following residual flows from generation through collection, treatment, and ultimate discharge. Such tracing establishes whether proposed treatment measures are adequate

to prevent unacceptable impacts.

¶6 **Impact linkage:** Connecting residual flow accounts to ecosystem condition accounts to assess how pollution loads affect ecosystem state. Where condition accounts record declining dissolved oxygen in a coastal zone whilst physical flow accounts record increasing nutrient loads, the pairing establishes an empirical pressure-state relationship that can inform EIA predictions for projects that would add nutrient loads.

3.3 Solid Waste

¶1 Solid waste accounts organise information on the generation of solid waste and the management of flows to recycling facilities, controlled landfills, or the environment¹⁷. For ocean accounting, the principal concern is marine litter – solid waste that enters the marine environment.

3.3.1 Marine litter and plastics

¶1 Marine litter comprises manufactured or processed solid material that enters the marine environment from any source¹⁸. SDG Target 14.1 calls for prevention and significant reduction of marine pollution of all kinds, including marine debris, with indicator 14.1.1 including floating plastic debris density¹⁹.

¶2 Plastic pollution is the dominant component of marine litter by item count and is of particular concern due to:

- ¶3 Persistence in the marine environment over decades to centuries
- ¶4 Fragmentation into microplastics (particles less than 5mm) that enter marine food webs
- ¶5 Accumulation in ocean gyres, coastal areas, and deep-sea sediments
- ¶6 Harm to marine fauna through ingestion and entanglement

¶7 The TNFD disclosure framework identifies plastic pollution as a specific metric for nature-related disclosure, including plastic footprint measured as total weight of plastics used or sold, disaggregated by reusable, compostable, and technically recyclable categories²⁰.

¶8 The international framework for plastic pollution management is evolving. The UN Environment Assembly initiated negotiations for an international legally binding instrument on plastic pollution (UNEA Resolution 5/14, 2022), which may establish new reporting requirements that complement ocean accounting frameworks. Compilers should monitor developments in this area.

3.3.2 Accounting for solid waste flows to marine environment

¶1 The SEEA solid waste account structure can be adapted for ocean accounting using the three approaches summarised in Table 3.3.2 below.

Approach	Description
Identifying marine leakage pathways	Waste that escapes from collection systems, landfills, or other waste management infrastructure and enters marine waters.
Recording direct dumping	Waste disposed directly into marine waters (regulated under the London Convention and Protocol).
Tracking coastal and riverine sources	Waste from coastal zones and rivers that enters the marine environment.

¶2 Compilation requires estimation of:

- ¶3 Waste generated by coastal industries and households
- ¶4 Share of mismanaged waste that reaches marine waters
- ¶5 Waste transported by rivers to the ocean
- ¶6 Waste generated by marine activities (shipping, fishing, offshore operations)

¶7 The European Waste Catalogue (EWC-Stat) classification provides a basis for categorising solid waste types, with particular attention to:

- ¶8 Plastic waste by polymer type and product category
- ¶9 Fishing gear (abandoned, lost, or discarded fishing gear – ALDFG)
- ¶10 Packaging waste
- ¶11 Single-use products

¶12 The SF-MST (Statistical Framework for Measuring the Sustainability of Tourism) provides guidance on tourism solid waste accounting that can inform measurement of coastal tourism waste generation²¹.

¶13 Plastic leakage estimation using the Jambeck approach

¶14 The Jambeck et al. (2015) methodology²² provides an accessible approach for estimating plastic waste leakage to the marine environment from land-based sources. The general formula is:

¶15 *Marine plastic leakage = Population in coastal zone × Waste generation rate (kg/person/year) × Share of plastic in waste × Share mismanaged × Share reaching marine environment*

¶16 Before applying this approach in a national account, compilers should verify that the following minimum data requirements are met:

- ¶17 A national waste characterisation study or official municipal solid waste (MSW) generation rate that establishes the per-capita waste generation rate and polymer composition of the waste stream. Where a recent national study is unavailable, regional benchmark data from the World Bank *What a Waste 2.0* report²³ may be used as a documented substitute.
- ¶18 An estimate of waste collection coverage (percentage of the coastal population served by formal collection), which is the primary driver of the “share mismanaged” parameter.

¶19 For the “share mismanaged” parameter, where country-specific data are unavailable, compilers should use the default values by income group in the reference table below, drawn from UNEP and World Bank sources. These values reflect the share of MSW that is inadequately managed (open dumping, burning, or uncontrolled disposal):

Country income group (World Bank classification)	Default share mismanaged (midpoint)	Indicative uncertainty range
Low income	0.90	0.80 – 0.99
Lower-middle income	0.52	0.35 – 0.70
Upper-middle income	0.22	0.10 – 0.40
High income	0.02	0.00 – 0.05

¶20 The original 2015 Jambeck coefficients for the “share reaching marine environment” parameter (ranging from 0.15 to 0.40 of mismanaged coastal waste) should be validated against more recent modelling estimates where available. Updated global plastic pollution models, including the SYSTEMIQ/UNEP analyses and the UNEP *Global Waste Management Outlook* (2024 edition)²⁴, provide revised leakage rate estimates by region and waste management system type. Where a compiler uses default coefficients, this should be documented in account metadata with a statement of the uncertainty range applied. Cross-reference with [TG-4.2 Survey Methods](#) for guidance on commissioning or interpreting national waste characterisation studies.

¶21 Abandoned, lost, or discarded fishing gear (ALDFG)

¶22 ALDFG is listed under the European Waste Catalogue classification and is specifically targeted by SDG 14.1 and the UN commitment on fishing gear marking. The following compilation note specifies how NSO compilers can produce a credible ALDFG estimate for inclusion in the solid waste supply side of the account.

¶23 *Step 1 – Gear inventory:* Use national fishing licence records and gear type declarations to establish the total quantity of gear in use, disaggregated by gear category (e.g., gillnets, longlines, pots and traps, drifting FADs, trawls). The FAO Voluntary Guidelines on the Marking of Fishing Gear (2019)²⁵ are the primary reference for gear inventory methodology and can be used to structure data collection from national licensing authorities.

¶24 *Step 2 – Apply gear-type-specific loss rates:* Apply published loss rate estimates from FAO/UNEP sources by gear type, for example:

- ¶25 Drifting FADs: 1-5% loss per deployment (Richardson et al., 2019)²⁶
- ¶26 Longlines: 0.1-0.5% loss per set
- ¶27 Gillnets and trammel nets: 0.5-3% annual loss of gear stock
- ¶28 Pots and traps: 0.5-2% annual loss

¶29 Where country-specific or regional loss rate data are available from observer programmes or gear recovery surveys, these take precedence over global defaults.

¶30 *Step 3 – Express result:* Calculate the result as tonnes of gear material by polymer type per year (nylon, polyethylene, polypropylene, etc.), applying gear-type-specific material composition factors.

¶31 *Step 4 – Record in account:* Record under the solid waste supply side attributed to fishing, specifically ISIC 0311 (Marine fishing) or ISIC 0312 (Freshwater fishing) depending on the species group and operating area. Cross-reference TG-4.2 Survey Methods for gear survey design guidance.

3.4 Compilation Procedure for Physical Flow Accounts

¶1 The physical supply and use table for residuals records the generation of residuals by economic units (supply) and their destination (use). Table 1 provides a residual flow account template for ocean-related economic activities following the SEEA CF structure²⁷.

¶2 **Table 1: Residual Flow Account Template (Physical Supply-Use)**

¶3 **SUPPLY OF RESIDUALS** (by generating industry)

Residual Type	Fishing (ISIC 03)	Aquaculture (ISIC 03)	Shipping (ISIC 50)	Ports (ISIC 52)	Processing (ISIC 10)	Offshore Energy (ISIC 06)	Tourism (ISIC 55-59)
<i>Air emissions</i>							
CO ₂ (tonnes)	45,000	2,000	850,000	15,000	120,000	180,000	8,000
SO _x (tonnes)	180	8	12,000	60	450	720	30
NO _x (tonnes)	320	15	18,000	110	680	1,100	55
<i>Water emissions</i>							
Nutrients – N (tonnes)	120	8,500	85	450	2,200	150	680
Nutrients – P (tonnes)	25	1,800	18	95	450	32	145
BOD (tonnes)	180	12,000	250	1,200	8,500	420	2,100
<i>Solid waste</i>							
Discarded catch (tonnes)	15,000	–	–	–	2,500	–	–
Plastic (tonnes)	450	85	1,200	320	680	125	2,800
General waste (tonnes)	850	220	5,600	2,400	4,200	950	8,500

¶4 *Note: totals are maintained per substance, never across substances. Adding tonnes of CO₂ to tonnes of nitrogen and tonnes of plastic produces a number with no physical meaning, and SEEA CF*

Table 3.1 specifies per-substance totals for that reason². The meaningful balancing check is that each substance row's supply equals its use.

¶5 **USE OF RESIDUALS** (by receiving medium or treatment)

Residual Type	Atmosphere	Direct discharge to coastal/marine water (point source)	Diffuse coastal runoff (non-point)	Riverine delivery (modelled/estimated)	Freshwater (drainage way-station)
CO ₂	1,245,000	—	—	—	—
SO _x	13,448	—	—	—	—
NO _x	20,280	—	—	—	—
Nutrients - N	—	3,200	2,100	3,900	[inland retention]
Nutrients - P	—	680	450	820	[inland retention]
BOD	—	7,200	5,500	7,800	[inland retention]
Discarded catch	—	7,000	2,500	2,750	—
Plastic	—	1,700	1,650	1,500	—
General waste	—	2,100	2,100	1,900	—

¶6 *Note: This is a worked example with synthetic data illustrating the account structure. The supply-use identity requires Total Supply = Total Use for each residual type. The "Collection & Treatment" column records residuals that are collected by waste management industries rather than released directly to the environment. The use side distinguishes three marine water pathways as separate columns: (a) Direct discharge to coastal/marine water (point source, permit-regulated); (b) Diffuse coastal runoff (non-point, estimated); and (c) Riverine delivery (transported via freshwater system, modelled or estimated). These three columns appear at the same level as "Atmosphere" and "Seabed": there is no consolidated "Marine Water" parent column in this table. A "Freshwater/Inland" column records residuals generated within drainage basins that have not yet reached the coast and acts as a way-station consistent with the drainage basin methodology in Section 3.5.3. Atmospheric emissions may subsequently deposit in marine waters but are recorded in the atmosphere use column following SEEA CF convention. See Table M1 in Section 3.2.2 for the supplementary atmospheric deposition memorandum table.*

¶7 *Data sources by use sub-column: (a) Direct discharge – discharge permit records, point-source monitoring; (b) Diffuse coastal runoff – land cover analysis, runoff modelling, stormwater monitoring; (c) Riverine delivery – river load monitoring, watershed modelling (e.g., Global NEWS). See TG-4.3 Administrative Data Sources.*

¶8 **What this one table stands in for.** The SEEA Central Framework specifies several separate physical flow accounts, each with its own table. This Circular compiles them as one ocean-scoped PSUT rather than reproducing each separately, because an ocean account needs the substances routed to a common set of marine receiving media and a compiler reconciling five tables to one boundary gains nothing. The correspondence is:

SEEA CF account	Where it appears here	Reconciling to a national account
Air emissions account	CO ₂ , SO _x , NO _x rows; Atmosphere use column	Row totals should equal the ocean-industry columns of the national air emissions account
Water emissions account	Nutrients, BOD rows; the three marine-water and freshwater use columns	Row totals should equal the national water emissions account for the same industries, with the marine split added here
Solid waste account	Discarded catch, plastic, general waste rows; Collection & Treatment and Recycling columns	Row totals should equal the national waste account for the same industries

SEEA CF account	Where it appears here	Reconciling to a national account
Energy flow account	Not compiled here	TG-3.10 Offshore Energy Accounts
Water flow account	Seawater abstraction is a natural input, not a residual	TG-3.2 Section 3.3.1; freshwater-marine interaction in TG-6.13

¶9 Where a country already publishes air, water-emission or waste accounts, compile this table by extracting and re-routing those rows rather than by independent estimation, and reconcile the totals. Where it does not, this table is the first of them.

3.4.1 Compilation steps

¶1 The compilation procedure for residual flow accounts follows these steps:

¶2 Step 1: Identify industries in scope

¶3 Determine which industries generate material quantities of residuals that reach marine waters, either directly or indirectly. Use the ISIC classification framework detailed in [TG-3.3 Economic Activity Relevant to the Ocean](#). At minimum, include:

- ¶4 Marine-based industries: fishing (ISIC 03), shipping (ISIC 50), offshore extraction (ISIC 06)
- ¶5 Coastal industries: aquaculture (ISIC 03), ports (ISIC 52), fish processing (ISIC 10), coastal tourism (ISIC 55-56)
- ¶6 Land-based sources: agriculture (ISIC 01), manufacturing (ISIC 10-33), sewerage (ISIC 37)
- ¶7 Households in coastal drainage basins

¶8 Step 2: Determine substance priorities

¶9 Select substances based on policy relevance, data availability, and environmental significance. Priority substances typically include:

- ¶10 Air emissions: CO₂, SO_x, NO_x (linked to acidification and deposition)
- ¶11 Water emissions: nitrogen, phosphorus, BOD, COD, heavy metals, oil
- ¶12 Solid waste: plastics (by type), fishing gear, general waste

¶13 Step 3: Compile supply-side data

¶14 For each industry-substance combination, estimate the quantity generated using:

- ¶15 Direct measurement from monitoring systems (e.g., continuous emissions monitoring)
- ¶16 Activity data × emission factors (e.g., fuel consumption × CO₂ coefficient)
- ¶17 Industry surveys and reporting systems
- ¶18 Administrative records (discharge permits, waste manifests)
- ¶19 Modelling (e.g., nutrient loading models for agriculture)

¶20 Sources are detailed in Section 4 (Data Sources and Compilation).

¶21 Step 4: Compile use-side data

¶22 Track the destination of residuals:

- ¶23 Atmosphere: all air emissions by convention
- ¶24 Marine water (direct discharge): point source releases directly to coastal or marine water
- ¶25 Marine water (diffuse coastal runoff): non-point source releases estimated from land cover and runoff data
- ¶26 Marine water (riverine delivery): loads transported via freshwater systems and modelled to reach the coast
- ¶27 Freshwater/Inland: residuals generated within drainage basins not yet delivered to marine waters

- ¶28 Seabed: dumped waste, settled solids
- ¶29 Collection & treatment: residuals entering waste management systems
- ¶30 Recycling: recovered materials

¶31 **Step 5: Balance supply and use**

¶32 Verify that Total Supply = Total Use for each substance. Discrepancies indicate:

- ¶33 Missing treatment/disposal pathways
- ¶34 Unaccounted intermediate flows (e.g., retention in soils or freshwater systems)
- ¶35 Measurement error requiring reconciliation

¶36 Where discrepancies arise between supply-side estimates (e.g., from industry surveys or emission factors) and use-side estimates (e.g., from water quality monitoring networks), the following reconciliation sub-steps apply in sequence:

¶37 **(i) Document** the size and sign of the discrepancy for each substance and each use column.

¶38 **(ii) Investigate** in priority order: first check for missing pathways (a residual category may have no assigned use column), then check for unaccounted intermediate flows, and finally investigate measurement error.

¶39 **(iii) Apply adjustments** to the side with lower data quality. Where one side is based on direct measurement (e.g., flow gauging and water quality sampling at a river mouth) and the other on modelled estimates, adjust the modelled side to reconcile with the measured side. Document the direction of the adjustment and the reason.

¶40 **(iv) Record adjustments in metadata**, including the pre-adjustment and post-adjustment values for each substance and the rationale for the adjustment applied.

¶41 **(v) Present a reconciliation statement** showing pre- and post-adjustment totals for each substance as a standard annex to the account publication. This facilitates time-series comparability and supports quality assurance review.

¶42 Cross-reference [TG-0.7 Quality Assurance](#) for general principles on reconciliation and documentation standards.

¶43 **Step 6: Extend with spatial disaggregation**

¶44 Where feasible, disaggregate accounts by:

- ¶45 Drainage basin (for land-based sources) – see Section 3.5.3
- ¶46 Marine area (coastal zone, EEZ zones)
- ¶47 Ecosystem receiving area (coral reef, mangrove, open water)

¶48 This spatial extension supports targeted pressure assessment and links to ecosystem condition accounts.

3.5 Attribution to Economic Sectors

¶1 A principle of environmental-economic accounting is the attribution of residual flows to the economic units responsible for their generation. This attribution enables:

- ¶2 Analysis of which industries contribute most to environmental pressures
- ¶3 Assessment of intensity (emissions per unit output or value added)
- ¶4 Policy targeting and evaluation
- ¶5 Responsibility allocation for environmental management

3.5.1 Classification framework

¶1 The International Standard Industrial Classification of All Economic Activities (ISIC) provides the standard framework for classifying economic units by industry²⁸. Detailed guidance on ISIC appli-

cation for ocean-related activities is provided in [TG-3.3 Economic Activity Relevant to the Ocean](#). Key industries for ocean-related residual flows include:

¶2 Primary industries

- ¶3 ISIC 01-03: Agriculture, forestry and fishing – sources of nutrient runoff, aquaculture discharges
- ¶4 ISIC 05-09: Mining and quarrying – offshore extraction discharges, drilling wastes

¶5 Manufacturing

- ¶6 ISIC 10-33: Manufacturing – industrial discharges, waste generation, including fish processing (ISIC 1020)

¶7 Utilities and waste management

- ¶8 ISIC 35: Electricity, gas, steam and air conditioning supply – cooling water discharges, emissions from power generation
- ¶9 ISIC 36-39: Water supply, sewerage, waste management – wastewater discharges, solid waste flows

¶10 Transport

- ¶11 ISIC 50: Water transport – vessel emissions and discharges, ballast water, operational waste
- ¶12 ISIC 52: Warehousing and support activities for transportation – port operations

¶13 Tourism and recreation

- ¶14 ISIC 55-56: Accommodation and food service – coastal tourism waste and wastewater
- ¶15 ISIC 79: Travel agency and related activities – tourism-related pressures
- ¶16 ISIC 93: Sports, amusement and recreation – marine recreation impacts

¶17 Construction

- ¶18 ISIC 41-43: Construction – coastal development, dredging, infrastructure installation

¶19 Table 2 provides an illustrative example of how key residual types can be attributed to the industries that generate them, following the ISIC classification used in [TG-3.3 Economic Activity Relevant to the Ocean](#).

¶20 **Table 2: Illustrative Attribution of Residual Types to Ocean Industries**

Residual Type	Primary Ocean Industries	Attribution Approach	Data Sources
CO2 emissions	Shipping (ISIC 50), Offshore energy (ISIC 06)	Fuel consumption data × emission factor	Fuel sales, vessel monitoring, IMO reporting
Nutrient loading (N, P)	Agriculture (ISIC 01), Aquaculture (ISIC 03)	Activity data × emission factor; nutrient balance models	Fertilizer sales, livestock numbers, aquaculture feed records
Plastic waste	Fishing (ISIC 03), Tourism (ISIC 55-56), Households	Waste surveys; consumption data × leakage rates	Waste characterisation studies, gear loss surveys
BOD/organic waste	Aquaculture (ISIC 03), Food processing (ISIC 10), Sewerage (ISIC 37)	Production data × waste coefficient; monitoring	Discharge permits, treatment plant records
Underwater noise	Shipping (ISIC 50), Construction (ISIC 42)	Vessel movements × acoustic profile; pile-driving events	AIS data, construction permits, acoustic modelling
Oil & petroleum	Shipping (ISIC 50), Offshore extraction (ISIC 06)	Spill records; operational discharge monitoring	Incident reports, platform monitoring

3.5.2 Attribution methodology

¶1 The physical supply table for residuals records the generation of residuals by industry sector, with the use table recording their destination (collection by waste management, flows to environment)²⁹. Key methodological considerations include:

1. ¶2

Point source versus non-point source – point sources can be directly attributed to specific industries, whilst non-point sources (e.g., agricultural runoff, urban stormwater) require modelling or allocation methods

2. ¶3

Direct versus indirect flows – industries may generate residuals that flow directly to the environment or that are collected by other economic units (e.g., sewerage industry) before environmental release

3. ¶4

Residence principle – following national accounts conventions, residual flows are attributed to the resident economic unit generating them, regardless of where the release occurs. This is particularly relevant for shipping, where vessel emissions in foreign or international waters are attributed to the country of the vessel operator's residence³⁰

4. ¶5

Territorial versus production-based attribution – the default boundary for TG-3.4 residual flow accounts is the territorial boundary, consistent with SEEA CF Chapter 2 conventions for environmental accounts (paragraphs 2.14–2.30). Production-based accounts are a supplementary presentation only. Both supply and use sides of the account must use the same boundary. Mixing boundaries will cause the supply-use identity to fail, and Table 1 will not balance.

Worked example – vessel CO₂ emissions under each boundary:

- ¶6 Under the territorial boundary, a foreign-flagged vessel emitting 500 tonnes CO₂ while transiting the national EEZ is included in the national account, whilst a nationally-flagged vessel emitting 2,000 tonnes CO₂ outside the EEZ is excluded.
- ¶7 Under the production-based (residence) boundary, the same nationally-flagged vessel's 2,000 tonnes CO₂ is included regardless of where the emissions occur, whilst the foreign-flagged vessel's 500 tonnes are excluded.
- ¶8 Compilers must apply one boundary consistently to both the supply side (industry emission totals) and the use side (marine area receiving the emissions). The SEEA Technical Note on Air Emissions provides further guidance on the residence principle³⁰.

5. ¶9

Consumption-based attribution – for a fuller assessment, consumption-based attribution allocates emissions embodied in imported goods to the consuming economy. This requires input-output analysis linking production emissions to final consumption³¹

3.5.3 Spatial attribution using drainage basins

¶1 A key challenge in ocean accounting is attributing land-based pollution flows to specific marine areas. Drainage basins (the geographic areas from which surface water flows to a common outlet such as a river mouth or coastal discharge point) provide a natural spatial framework for linking terrestrial economic activity to marine pollution pressures³². By overlaying information on economic activity and population distribution with drainage basin boundaries, compilers can estimate the contributions of specific land areas to residual flows reaching the coast.

¶2 Allocation from national totals

¶3 Where SEEA CF water emission accounts or solid waste accounts have been compiled at the national level, these totals can be allocated to drainage basins using spatially detailed indicators of economic activity. For example, if the national water emissions account records that agriculture generates 5,000 tonnes of biological oxygen demand (BOD) per year, and a particular drainage basin contains 60% of the nation's agricultural employment, an initial estimate of BOD generated

by agriculture in that basin would be 3,000 tonnes per year. This activity-proportional allocation approach can be applied to any industry for which suitable spatial indicators are available, such as employment counts, output data, or land-use statistics³³.

¶4 The allocation formula is:

¶5 *Residual flow in basin i = National residual flow × (Activity indicator in basin i / National activity indicator)*

¶6 Example spatial indicators by industry:

- ¶7 Agriculture (ISIC 01): agricultural employment, fertiliser sales by district, irrigated area
- ¶8 Manufacturing (ISIC 10–33): industrial employment, facility locations, output by region
- ¶9 Households: population in drainage basin, housing units
- ¶10 Aquaculture (ISIC 03): licensed farm locations, production tonnage by basin

¶11 **Method validity check**

¶12 Activity-proportional allocation assumes that emission intensity per unit of activity is broadly uniform across basins. This assumption holds reasonably well when the spatial distribution of key drivers (crop type, technology mix, soil class, and management practice) is relatively homogeneous. It breaks down when documented heterogeneity exists across basins: for example, a coastal basin with intensive irrigated rice cultivation will have materially different nitrogen leaching coefficients from an inland basin with dryland cropping, even if both have similar agricultural employment totals.

¶13 Where spatial heterogeneity in emission intensity is likely to be pronounced, compilers should apply one of the following alternatives, in order of preference:

¶14 **(a) Facility-level data for point sources** – where individual facility emission data are available (discharge permits, monitoring records), these take precedence over proportional allocation for point sources.

¶15 **(b) Land-cover-differentiated emission factors for agriculture** – apply separate emission factors by crop type and management system (e.g., paddy rice, dryland cereal, irrigated vegetables) rather than a single national average, using land cover or agricultural census data disaggregated by basin.

¶16 **(c) Documented assumption with bias direction** – where heterogeneity is known but alternatives are unavailable, continue to use the proportional allocation method but document in account metadata that the assumption is likely to (overstate/understate) loads in particular basins, and in which direction.

¶17 **Bottom-up estimation from activity data**

¶18 Where no SEEA CF flow accounts exist at the national level, compilers can estimate residual flows by applying per-unit emission or waste generation factors to spatially detailed data on economic activity and population. For example, if 5,000 people reside within a drainage basin and the estimated per-capita generation rate of untreated solid waste is 0.365 tonnes per year, the population in that basin generates approximately 1,825 tonnes of untreated solid waste annually. Such per-capita and per-unit factors may be drawn from national waste surveys, regional studies, or international benchmarks and applied to census or administrative data at the drainage basin level.

¶19 General formula:

¶20 *Residual flow = Activity level × Emission/waste factor*

¶21 Example emission factors:

- ¶22 Nutrient loading from agriculture: kg N per hectare of fertilised cropland
- ¶23 BOD from households: kg BOD per capita per year for unsewered population
- ¶24 Plastic waste: kg plastic per capita per year × share mismanaged × share reaching marine environment

¶25 **Delivery ratio: tiered fallback methodology**

¶26 Not all residuals generated within a drainage basin reach the ocean. Soils retain some pollutants and vegetation absorbs others. Freshwater systems store a further portion, and transport losses reduce the quantities that remain. Treatment systems (sewerage networks, wastewater treatment plants) intercept and process portions of the load before discharge. The delivery ratio is the

proportion of residuals generated within the basin that are estimated to reach marine waters. Compilers should apply the following tiered fallback methodology when a delivery ratio is required:

¶27 **Tier 1 – National hydrology agency data:** If a government hydrology agency or national environmental authority has published delivery ratios for river basins or pollutant types (e.g., from a national water quality model or regulatory catchment assessment), these values should be applied and cited as the primary source.

¶28 **Tier 2 – Published regional defaults:** Where Tier 1 data are unavailable, use published regional default delivery ratios from sources including:

- ¶29 The Global NEWS (Nutrient Export from WaterSheds) model, which provides nitrogen, phosphorus, and organic carbon delivery coefficients by river basin globally (Mayorga et al., 2010)³⁴
- ¶30 FAO AQUASTAT nutrient export coefficients, which provide country- and region-level estimates for nitrogen and phosphorus delivery to water bodies

¶31 **Tier 3 – Conservative default (1.0):** Where neither Tier 1 nor Tier 2 data are available, treat the delivery ratio as 1.0, meaning that all generated residuals are assumed to reach marine waters. This is a conservative overestimate and will tend to overstate coastal loads. Accounts compiled using Tier 3 must be labelled in metadata as reporting “generated load, not delivered load”. SEEA CF-consistent accounts may use this approach provided the labelling is clear and the assumption is documented.

¶32 A formal metadata field distinguishing generated residuals (all sources within the basin, prior to delivery adjustment) from delivered residuals (the portion estimated to reach marine waters) should be included in all drainage basin accounts. This distinction is relevant to policy users comparing accounts across countries or jurisdictions, where different delivery ratio approaches may have been applied.

¶33 For example, if agricultural activities generate 3,000 tonnes BOD per year in a drainage basin, and watershed modelling (Tier 1) indicates a 35% delivery ratio, the delivered load is 1,050 tonnes BOD per year. If no delivery ratio data are available, the Tier 3 entry would record 3,000 tonnes as generated load with a metadata flag.

¶34 **Marine redistribution**

¶35 Conversely, residuals that do reach the ocean may not remain at the point of coastal discharge, as ocean currents, tides, and biogeochemical processes redistribute pollutants over time and space. Further dispersion modelling would be required for more precise estimates of marine pollution loading and exposure patterns. Nonetheless, linking land-based sources of pollution with coastal and marine conditions through drainage basin attribution is a first step in connecting economic drivers to environmental outcomes.

¶36 **Implementation guidance**

¶37 Including terrestrial and freshwater areas in the spatial database underlying ocean accounts facilitates estimation of land-based sources of pollution and supports integrated catchment-to-coast analysis as outlined in [TG-3.1 Asset Accounts](#). Practical steps include:

1. ¶38 Obtain drainage basin boundaries from hydrological datasets (national water agencies, HydroSHEDS, regional GIS layers)
2. ¶39 Overlay economic activity data (employment, facilities, land use) using GIS
3. ¶40 Calculate activity shares by basin for each relevant industry
4. ¶41 Apply shares to national residual flow totals, or apply emission factors to basin-level activity data
5. ¶42 Adjust for treatment coverage and delivery ratios where data permit (see tiered fallback methodology above)

6. ¶43 Document methodology, data sources, and assumptions in account metadata, including which delivery ratio tier was applied and whether the account reports generated or delivered residuals

¶44 This methodology supports policy analysis by identifying:

- ¶45 Which drainage basins contribute most to coastal pollution
- ¶46 Which industries within priority basins require intervention
- ¶47 Where land-use planning and waste infrastructure investments would have greatest marine benefit

¶48 Guidance on linking these residual flow estimates to marine ecosystem condition and pressure indicators is provided in [TG-2.7 Pollution and Other Flows to Environment](#).

Land-to-sea attribution across the coastal interface

¶1 Accounts that span the land-sea interface require Basic Spatial Units harmonised across the terrestrial and marine domains, and a rule for apportioning terrestrial pressures to the marine units that receive them. The recommended approach is **drainage basin allocation**: identify the sub-catchments draining to each coastal BSU, then apportion terrestrial pressures (nutrient loading, sediment, pollutants) to marine receiving BSUs using a hydrological weighting factor derived from relative catchment area and runoff volume. GIS intersection is the standard technical method for this attribution. For first compilations, mapping coastal watershed polygons to the nearest marine BSU is an acceptable simplification. BSU design should match the resolution of available data, with no fixed resolution prescribed. BSU design follows **TG-2.12 Spatial Data Frameworks** Section 3.3; see also ESCAP (2021) *Ocean Accounts: Piloting the SEEA EEA for the Ocean*, Chapter 3, and SEEA EA paras 3.29–3.44. The integrated coastal management use of this attribution is set out in **TG-1.4 OA and Sustainable Ocean Planning** Section 3.5.

3.6 Physical Pressures

¶1 Beyond material pollution, economic activities exert physical pressures on marine ecosystems that do not involve material flows but nonetheless affect ecosystem condition and function. These pressures are recognised in ecosystem accounting frameworks, including SEEA Ecosystem Accounting guidance on ecosystem condition indicators³⁵.

3.6.1 Underwater noise

¶1 Anthropogenic underwater noise is a marine pressure of particular relevance to marine mammals and other species that rely on acoustic communication and echolocation³⁶. Table 3.6.1 below summarises the principal sources.

Source	Description
Shipping	Continuous low-frequency noise from vessel propulsion and machinery.
Seismic surveys	High-intensity impulsive noise from airguns used in oil and gas exploration.
Pile driving	High-intensity impulsive noise from construction of offshore infrastructure including wind farms.
Sonar	Military and commercial sonar systems.
Dredging and drilling	Operational noise from coastal and offshore construction.

¶2 The Classification of Environmental Protection Activities (CEPA) includes noise and vibration abatement (CEPA 5), covering activities aimed at control, reduction, and abatement of industrial and transport noise³⁷. For ocean accounting, this framework can be adapted to address underwater noise from maritime activities.

¶3 Accounting for underwater noise requires:

- ¶4 Identification of noise-generating activities and their acoustic characteristics
- ¶5 Spatial mapping of noise exposure in marine areas
- ¶6 Attribution to economic sectors responsible for noise generation
- ¶7 Recording of mitigation measures (e.g., speed reductions, operational restrictions, noise barriers)

¶8 Underwater noise measurement remains an emerging field with limited standardisation. The IMO has developed voluntary guidelines for reducing underwater noise from commercial shipping (MEPC.1/Circ.833)³⁸, and several regional seas conventions have adopted noise monitoring indicators, including EU MSFD Descriptor 11, which establishes a good environmental status criterion for ambient noise levels. Until a standardised acoustic unit is adopted internationally, compilers should use the following primary proxy indicators for NSO compilation:

- ¶9 **Shipping noise:** AIS-derived vessel density (vessel-hours per km² per year) within the national EEZ or defined marine accounting area, attributed to Water Transport (ISIC 50). This proxy represents the spatial and temporal pattern of shipping activity (the primary driver of continuous low-frequency noise), using existing AIS data that many NSOs or coast guard authorities already receive.
- ¶10 **Construction noise:** Number of pile-driving events per year, attributed to Construction (ISIC 42) or Electricity/gas supply (ISIC 35) for offshore wind installations.

¶11 A secondary recommended indicator, to be compiled where acoustic monitoring data are available, is the percentage of the national EEZ exceeding an ambient noise threshold (expressed in dB re 1 µPa in a defined frequency band). This indicator is flagged as emerging and subject to methodological revision as international standardisation develops. Compilers using this secondary indicator should document the threshold, frequency band, and monitoring method in account metadata and cross-reference [TG-0.7 Quality Assurance](#) for the treatment of experimental indicators.

3.6.2 Light pollution

¶1 ⓘ Future Directions

¶2 **Artificial light at night (ALAN) as a marine pressure indicator – not yet compilable at NSO level**

¶3 Artificial light at night affects marine and coastal ecosystems by disrupting navigation, reproduction, and predator-prey relationships for marine species including sea turtles, seabirds, and coral spawning³⁹. Sources include coastal urban lighting, offshore platform lighting, vessel lighting, and fishing operations using light attraction.

¶4 At the time of this Circular's publication, light pollution has not been adopted as a statistical standard within the SEEA CF or SEEA EA frameworks, and no CEPA classification covers light pollution. An NSO compiler cannot yet derive a light pollution account that is compliant with an agreed international standard. This section is therefore designated as a future direction and compilers are advised not to treat it as a current data requirement.

¶5 **Single operational proxy for monitoring purposes:** Compilers seeking to develop a supplementary earth observation indicator may use VIIRS (Visible Infrared Imaging Radiometer Suite) Day/Night Band night-light radiance, expressed in nW/cm²/sr, aggregated over the coastal zone and offshore platform locations within the national accounting area. VIIRS DNB data are available from the NOAA/NCEI Earth Observations Group at 750 m resolution and cover the period from 2012 onwards, enabling time-series construction. This indicator is derived from earth observation and is not an economic accounting flow. It should be presented separately from the core residual flow account.

¶6 Full accounting treatment of light pollution as an economic-to-environment flow, including industry attribution and classification standards, is deferred to a future revision of this Circular pending development of an appropriate statistical standard. See [TG-4.1 Remote Sensing and Geospatial Data](#) for guidance on integrating satellite-derived supplementary indicators into the ocean accounts system.

3.6.3 Habitat disturbance

¶1 Physical disturbance of marine habitats results from activities summarised in Table 3.6.3 below.

Activity	Description
Bottom trawling	Physical impact on seabed habitats from mobile fishing gear.
Dredging	Removal of sediments from ports, channels, and coastal areas.
Coastal development	Construction affecting coastal and nearshore habitats.
Cable and pipeline installation	Seabed disturbance from infrastructure installation.
Anchoring	Localised damage from vessel anchoring, particularly on sensitive habitats such as seagrass and coral.

¶2 The SEEA Ecosystem Accounting framework addresses ecosystem modification and habitat disturbance as factors affecting ecosystem condition³⁵. For ocean accounting, physical pressures should be recorded in terms of:

- ¶3 Area affected by disturbance type and economic activity
- ¶4 Intensity or severity of disturbance
- ¶5 Recovery status where applicable

¶6 Guidance on linking physical pressures to ecosystem condition accounts is provided in [TG-3.1 Asset Accounts Section 3.5.2](#).

3.7 Combined Presentations and Indicators

¶1 The SEEA framework supports combined presentations that bring together physical and monetary data to enable derivation of indicators⁴⁰. For residual flows to the marine environment, combined presentations would include:

¶2 **Table 3: Combined Presentation Framework for Ocean-Related Residual Flows**

Data Element	Physical Units	Monetary Units
Output by industry	tonnes, units	Currency
Gross value added by industry	–	Currency
Employment by industry	Persons, FTE	–
Emissions to water by substance	tonnes	–
Emissions to air by substance	tonnes	–
Solid waste generated	tonnes	–
Waste management expenditure	–	Currency
Environmental protection expenditure	–	Currency
Environmental taxes paid	–	Currency

¶3 Methodology note for intensity indicators

¶4 The following methodological specifications apply when deriving intensity indicators from Table 3:

¶5 **(a) Economic denominator:** Use gross value added (GVA) at basic prices, current prices, for the same reference year as the physical account. GVA at basic prices is the recommended aggregate for industry-level analysis as it excludes taxes on products, which vary across industries and jurisdictions (SNA 2025, Chapter 6)⁴¹. The relevant national accounts aggregate should match the ISIC industry classification in the physical account.

¶6 **(b) Industry classification:** Industry classification for GVA denominators follows ISIC, consistent with [TG-3.3 Economic Activity Relevant to the Ocean](#). Where national accounts publish GVA at a more aggregated ISIC level than the physical account, compilers should document the correspondence applied.

¶7 **(c) Households:** Households have no GVA. For household-generated residuals, use household final consumption expenditure as the economic denominator, or present household residuals on a per capita basis as an alternative intensity measure. Do not leave the household row blank in the intensity table. Flag the denominator used.

¶8 **(d) Accounting period:** The default accounting period is the calendar year (1 January to 31 December). Where national accounts are compiled on a fiscal year basis that differs from the calendar year, document the adjustment applied to align physical and monetary data for the intensity calculation.

¶9 From such presentations, indicators can be derived including:

- ¶10 **Emissions intensity:** emissions per unit GVA or output (e.g., kg N per million currency of aquaculture output)
- ¶11 **Waste generation intensity:** tonnes waste per FTE (e.g., kg plastic per employee in fishing industry)
- ¶12 **Environmental expenditure share:** environmental expenditure as percentage of industry output
- ¶13 **Decoupling indicators:** tracking emissions relative to economic growth (e.g., ratio of emission growth rate to GDP growth rate)

¶14 Example derived indicators:

Industry	Nutrient Loading (tonnes N)	Gross Value Added (million currency, basic prices)	Intensity (kg N per million GVA)
Aquaculture (ISIC 03)	8,500	450	18,889
Agriculture (ISIC 01)	85,000	2,300	36,957
Households	3,200	– (use per capita: 3,200 t N ÷ population)	–

¶15 In this example, whilst agriculture generates a larger absolute load, aquaculture has lower emissions intensity per unit of economic output. Such indicators support:

- ¶16 Benchmarking across industries and jurisdictions
- ¶17 Monitoring progress toward pollution reduction targets
- ¶18 Identifying high-intensity activities for policy intervention
- ¶19 Evaluating effectiveness of environmental protection expenditure

¶20 Guidance on indicator derivation and interpretation is provided in [TG-2.7 Pollution and Other Flows to Environment](#) and [TG-2.11 Resource Efficiency](#).

3.8 Cross-Stack Connections

¶1 Residual flow accounts sit at the centre of an integrated information system linking economic drivers, environmental pressures, ecosystem condition, and policy responses:

¶2 **Upward connections (to indicators and policy frameworks):**

- ¶3 [TG-2.7 Pollution and Other Flows to Environment](#) – derives pressure indicators from residual flow data (nutrient loading rates, plastic leakage, emission trends)
- ¶4 [TG-2.8 Climate Change Indicators](#) – links CO₂ emissions to ocean acidification indicators and climate-related marine impacts
- ¶5 [SDG 14.1.1](#) – coastal eutrophication index draws on nutrient loading data, whilst floating plastic debris density draws on plastic waste flows
- ¶6 [TNFD disclosures](#) – plastic pollution metrics and pollution-related dependencies

¶7 **Downward connections (to data sources):**

- ¶8 TG-4.2 Survey Methods – industry surveys on waste generation, environmental practices
- ¶9 TG-4.3 Administrative Data – discharge permits, compliance monitoring, waste manifests, ship reporting systems
- ¶10 TG-4.1 Remote Sensing and Geospatial Data – satellite detection of oil spills, floating debris, coastal development
- ¶11 National pollution inventories, water quality monitoring networks, marine litter surveys

¶12 **Lateral connections (to related physical accounts):**

- ¶13 TG-3.1 Asset Accounts – links residual flows to changes in asset quality (water quality degradation, seabed contamination)
- ¶14 TG-3.2 Flows from Environment to Economy – contrasts resource extraction flows with waste return flows
- ¶15 TG-3.3 Economic Activity – provides ISIC framework for industry attribution

¶16 Through these connections, residual flow accounts contribute to a coherent analytical framework.

3.9 Monetary Valuation of Residual Flows

¶1 Residual flows from the economy to the marine environment are recorded primarily in physical terms in the SEEA Central Framework. Monetary valuation of these flows is not required by the SEEA CF but is sometimes attempted in supplementary analyses, particularly where the same residual is also an ecosystem-service disservice (for example, greenhouse-gas emissions reducing the global climate regulation service of the ocean) or where compilers wish to express pressures in monetary units to support cost-benefit analysis and integrated reporting. The NCAVES/MAIA technical guidance on monetary valuation⁴², although developed for ecosystem-service flows in the SEEA EA, provides the most coherent published set of patterns for valuing the marine impacts of residual flows.

3.9.1 Exchange-value framing for residual flows

¶1 The same exchange-value concept that governs ecosystem-service valuation in TG-3.2 Flows from Environment to Economy applies in principle to residual flows: where a market price for the right to discharge exists (for example, allowances under a regulated emissions trading system), that price represents an exchange value and can be used directly. Where no such market exists, valuation must fall back on revealed-expenditure or simulated-expenditure methods. Compilers should be alert to the distinction between **exchange values** (usable in monetary accounts) and **welfare values** such as willingness to pay to avoid the residual, which include consumer surplus and are conceptually distinct from accounting prices⁴³. Where stated-preference techniques are the only feasible source of evidence, the **simulated exchange value (SEV)** method can in principle be used to convert welfare estimates to accounting-consistent prices, though this remains a frontier application.

3.9.2 Candidate valuation methods by residual type

¶1 For tiered valuation approaches and the NCAVES framework for selecting candidate methods by residual category, see TG-3.2 Flows from Environment to Economy, Section 3.5. None of those methods is required by SEEA CF. All should be treated as candidate workflows accompanied by clear documentation of methods, assumptions, and uncertainties. The replacement cost and avoided damage cost methods are valid proxies for exchange value only where three conditions hold: the alternative or damage measure corresponds to the actual function being valued, it represents the least-cost option, and there is evidence that society would in fact undertake the response⁴⁴.

3.9.3 Asset-side implications and discount rate

¶1 Where residual flows degrade ecosystem condition, they reduce the future supply of ecosystem services and therefore reduce the **net present value (NPV)** of the affected ecosystem asset. This is the **degradation** concept in SEEA EA: monetary degradation equals the change in asset value attributable to the decline in condition. The NPV calculation requires both a projected future flow path and a discount rate.

¶2 For discount rate selection (including the Ramsey decomposition, the distinction between market-based and social discount rates, plausible SDR ranges, and government guidance schedules), see **TG-1.9 Safe Usage of Monetary Valuation** Section 3.1.2. Compilers attempting damage-side valuations of residual flows should adopt rates specified in relevant national guidance, document the choice, and present sensitivity analyses across at least two alternative rates consistent with TG-1.9 Section 3.1.2.

¶3 **⚠ Common Misconception**

¶4 The **social cost of carbon (SCC)** is a welfare measure, not an exchange value. Use ETS prices or marginal abatement cost estimates for accounting-consistent carbon pricing⁴⁵. See **TG-3.2 Flows from Environment to Economy** Section 3.5 for the full exchange-value versus welfare-value treatment.

¶5 These valuations remain a frontier area for ocean accounting. The NCAVES guidance is explicit that monetary valuation of pressures and damages should be undertaken cautiously, with full disclosure of methods and uncertainty, and should not displace the underlying physical accounts that remain the primary record of residual flows under the SEEA CF.

4. Data Sources and Compilation

¶1 Compilation of residual flow accounts for ocean accounting draws on multiple data sources. **TG-4.3 Administrative Data** provides detailed guidance on administrative data sources for ocean accounting.

¶2 Key data sources include:

¶3 **Environmental monitoring data**

- ¶4 National pollution inventories and emission reporting systems
- ¶5 Water quality monitoring networks (coastal stations, estuarine monitoring)
- ¶6 Marine litter surveys and monitoring programmes
- ¶7 Beach cleanup data and citizen science initiatives

¶8 **Administrative records**

- ¶9 Discharge permits and compliance monitoring (point sources)
- ¶10 Waste management records and tracking systems
- ¶11 Port reception facility records (MARPOL waste from vessels)
- ¶12 Ship monitoring and reporting systems (fuel consumption, ballast water exchange)
- ¶13 Aquaculture licensing and feed records

¶14 **Survey data**

- ¶15 Industry surveys on environmental practices
- ¶16 Waste characterisation studies
- ¶17 Tourism surveys for visitor-generated waste estimation
- ¶18 Fishing gear loss surveys

¶19 **Modelling and estimation**

- ¶20 Atmospheric deposition models (linking air emissions to marine deposition)
- ¶21 River loading models (watershed models estimating pollutant delivery)

- ¶22 Waste leakage models (e.g., Jambeck methodology for plastic waste)²²
- ¶23 Nutrient balance models for agriculture

¶24 International reporting frameworks

- ¶25 UNFCCC greenhouse gas inventories (CO₂, CH₄, N₂O by sector)
- ¶26 UNECE Convention on Long-Range Transboundary Air Pollution reporting
- ¶27 Regional seas convention reporting (e.g., OSPAR, HELCOM, Barcelona Convention)
- ¶28 IMO reporting under MARPOL (vessel discharges and emissions)

¶29 Example data pathway 1: Nutrient loading from agriculture

1. ¶30 **Activity data:** Agricultural census provides hectares of cropland by district and drainage basin
2. ¶31 **Emission factor:** National studies estimate 45 kg N per hectare leached from fertilized cropland
3. ¶32 **Initial estimate:** 10,000 hectares in Coastal Basin A × 45 kg N/ha = 450,000 kg N generated
4. ¶33 **Delivery adjustment:** Watershed model indicates 35% delivery ratio to coast → 157,500 kg N delivered
5. ¶34 **Account entry:** Agriculture (ISIC 01) in Basin A contributes 157.5 tonnes N to coastal waters

¶35 Example data pathway 2: Plastic waste to marine environment

1. ¶36 **Activity data:** National MSW statistics provide total waste generation (tonnes/year) for the coastal population. Apply waste characterisation study results (or World Bank *What a Waste 2.0* regional benchmark) to derive the plastic fraction in tonnes.
2. ¶37 **Mismanaged share:** Apply the income-group default “share mismanaged” from the reference table in Section 3.3.2 (the income-group default table under “Accounting for solid waste flows to marine environment”), or country-specific collection coverage data if available.
3. ¶38 **Leakage coefficient:** Apply the Jambeck “share reaching marine environment” coefficient for the coastal population (validate against updated SYSTEMIQ/UNEP estimates where available).
4. ¶39 **Marine litter estimate:** Tonnes plastic mismanaged × leakage coefficient = estimated marine plastic leakage per year.
5. ¶40 **Reconciliation note:** Where beach monitoring data or river plastic flux monitoring are available, present a reconciliation comparison between the model estimate and observed data and document any adjustment applied.
6. ¶41 **Account entry:** Record under solid waste supply side attributed to Households and relevant coastal industries (ISIC 55–56, ISIC 37), disaggregated by coastal drainage basin where feasible.

¶42 Example data pathway 3: Vessel emissions (CO₂, SO_x, NO_x)

1. ¶43 **Activity data:** Obtain fuel consumption data for vessels operating in national waters from one or more of: (a) MARPOL Annex VI fuel oil consumption data collection (mandatory for ships ≥5,000 GT); (b) AIS-derived engine hours combined with vessel-specific engine power and fuel consumption rates; (c) port authority bunkering records.
2. ¶44 **Boundary decision:** Decide whether the account uses the territorial boundary (all emissions within the EEZ, regardless of vessel flag) or the production-based boundary (all emissions by resident vessel operators, regardless of location). Document the choice and apply it consistently to both supply and use sides of Table 1 (see Section 3.5.2).
3. ¶45 **Emission factors:** Apply IMO Tier II emission factors by fuel type and vessel category (from the IMO Fourth Greenhouse Gas Study 2020)⁴⁶ to fuel consumption data to derive CO₂, SO_x, and NO_x in tonnes.

4. ¶46 **Supply attribution:** Attribute to Shipping (ISIC 50) – Water transport, disaggregating between international and domestic voyages where possible.
5. ¶47 **Use side:** CO₂ to Atmosphere use column; SO_x and NO_x to Atmosphere use column (with supplementary atmospheric deposition estimate in Table M1 if desired).
6. ¶48 **Account entry:** Record in Table 1, Air emissions rows, with a metadata note on boundary choice and data source.

¶49 Quality assurance considerations for residual flow accounts are addressed in [TG-0.7 Quality Assurance](#).

5. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

6. References

1. ¶1 United Nations et al. (2014). *System of Environmental-Economic Accounting 2012 – Central Framework*. New York: United Nations.
2. ¶2 SEEA CF, Chapter III, Section 3.2, paragraphs 3.17–3.40.
3. ¶3 SEEA CF, paragraph 2.92 and 3.73.
4. ¶4 SEEA CF, paragraphs 3.88–3.95.
5. ¶5 SEEA CF, paragraph 3.92.
6. ¶6 SEEA CF, paragraphs 3.260–3.267.
7. ¶7 UN Statistics Division. SDG Indicator 14.1.1: Index of coastal eutrophication and floating plastic debris density.
8. ¶8 FAO and UNSD (2020). *System of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries (SEEA AFF)*. Section 4.5 on nutrient flow accounts.
9. ¶9 GESAMP (2019). *Guidelines for the monitoring and assessment of plastic litter in the ocean*. GESAMP Reports and Studies No. 99 (eds. Kershaw, Turra & Galgani). The primary microplastics assessment is GESAMP Reports and Studies No. 90 (2016).
10. ¶10 SEEA Technical Note: Water Accounting (2017), Section 2.1.4 on water emissions.
11. ¶11 SEEA CF, paragraph 3.91.
12. ¶12 SEEA Technical Note: Air Emissions Accounting (2016), paragraphs 17–20.
13. ¶13 SEEA Ecosystem Accounting (2021), Chapter 13 on thematic accounts, particularly Section 13.4 on climate change, including Figure 13.1 on the carbon cycle.
14. ¶14 Adapted from SEEA Ecosystem Accounting (2021), Figure 13.1: Main components of the carbon cycle.
15. ¶15 International Maritime Organization. International Convention for the Prevention of Pollution from Ships (MARPOL).
16. ¶16 IMO Ballast Water Management Convention (2004, in force 2017). D-2 standard specifies biological treatment requirements for ballast water discharge.
17. ¶17 SEEA CF, paragraphs 3.268–3.278.
18. ¶18 GESAMP (2019). *Guidelines for the monitoring and assessment of plastic litter in the ocean*. GESAMP Reports and Studies No. 99 (eds. Kershaw, Turra & Galgani).
19. ¶19 UN Statistics Division. SDG Target 14.1 and Indicator 14.1.1.
20. ¶20 TNFD (2023). *Recommendations of the Taskforce on Nature-related Financial Disclosures*, Metric C2.3: Plastic pollution.
21. ¶21 UNWTO and UNSD (2023). *Statistical Framework for Measuring the Sustainability of Tourism (SF-MST)*. Section 4.2.3 on solid waste accounting.
22. ¶22 Jambeck, J.R. et al. (2015). Plastic waste inputs from land into the ocean. *Science*, 347(6223): 768–771.
23. ¶23 Kaza, S. et al. (2018). *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*. Washington DC: World Bank. ISBN 9781464813290.
24. ¶24 UNEP (2024). *Global Waste Management Outlook 2024*. Nairobi: United Nations Environment Programme.
25. ¶25 FAO (2019). *Voluntary Guidelines on the Marking of Fishing Gear*. Rome: Food and Agriculture Organization of the United Nations. Adopted by COFI 33rd session, July 2018.
26. ¶26 Richardson, K. et al. (2019). Estimates of fishing gear loss rates at a global scale: a literature review and meta-analysis. *Fish and Fisheries*. doi: 10.1111/faf.12407.
27. ¶27 SEEA CF, Table 3.1: General physical supply and use table (Chapter III, paragraphs 3.17–3.40), with residual flows defined in paragraphs 3.73–3.87.

8. ¶28 United Nations (2008). *International Standard Industrial Classification of All Economic Activities, Revision 4*. Statistical Papers Series M No. 4/Rev.4.
9. ¶29 SEEA CF, paragraphs 3.260–3.267 (water emissions) and 3.268–3.277 (solid waste).
0. ¶30 SEEA Technical Note: Air Emissions Accounting (2016), paragraphs 25–27 on residence principle for transport emissions.
1. ¶31 SEEA Applications and Extensions, Chapter 4 on input-output analysis and consumption-based accounts.
2. ¶32 GOAP Technical Guidance on Ocean Accounts (2024). The drainage basin approach to spatial attribution draws on the SEEA CF combined presentations principles (paragraphs 2.80–2.84, which note the potential for regional disaggregation) and the spatial frameworks discussed in [TG-3.1 Asset Accounts](#) and [TG-0.3 Spatial and Temporal Frameworks](#).
3. ¶33 SEEA CF, paragraphs 2.80–2.84 on combined presentations (which note the potential for regional disaggregation), and SEEA Applications and Extensions, Chapter 5 on sub-national and spatial analysis.
4. ¶34 Mayorga, E. et al. (2010). Global Nutrient Export from WaterSheds 2 (NEWS 2): Model development and implementation. *Environmental Modelling & Software*, 25(7): 837–853.
5. ¶35 SEEA Ecosystem Accounting (2021), Chapter 5 on ecosystem condition. See also Appendix A3 (paragraphs A3.27–A3.28) on marine-specific pressures including noise and habitat disturbance.
6. ¶36 SEEA Ecosystem Accounting (2021), Appendix A3 (paragraphs A3.27–A3.28) on marine ecosystem pressures including noise; and Chapter 5 on ecosystem condition assessment.
7. ¶37 Classification of Environmental Protection Activities and Expenditure (CEPA), Class 5: Noise and vibration abatement.
8. ¶38 IMO MEPC.1/Circ.833 (2014). Guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life. Revised guidelines adopted 2023.
9. ¶39 Longcore, T. and Rich, C. (2004). Ecological light pollution. *Frontiers in Ecology and the Environment*, 2(4): 191–198.
0. ¶40 SEEA CF, Chapter VI on integrating and presenting the accounts.
1. ¶41 United Nations et al. (2025). *System of National Accounts 2025*, Chapter 6 on gross value added at basic prices.
2. ¶42 NCAVES & MAIA (2022). *Monetary Valuation of Ecosystem Services and Assets for Ecosystem Accounting: Interim Version, 1st Edition*. United Nations Statistics Division. The interim guidance compiled under the NCAVES and MAIA projects synthesises valuation methods for SEEA EA implementation.
3. ¶43 NCAVES & MAIA (2022), Chapter 2. The distinction between exchange values (consistent with the SNA) and welfare values (including consumer surplus and non-use values) is foundational, and the simulated exchange value method is the recommended bridge where only stated-preference data exist.
4. ¶44 NCAVES & MAIA (2022), Chapter 3; SEEA Valuation Guidelines paras 973–987. The validity conditions for replacement cost and avoided damage cost methods include equivalence of service, least-cost alternative, and demonstrated demand or willingness to bear the cost.
5. ¶45 NCAVES & MAIA (2022), Chapter 4 (global climate regulation). The SEEA EA recommends ETS prices or marginal abatement cost estimates aligned with national emissions commitments as exchange-value-consistent carbon prices. The social cost of carbon is a welfare measure used in policy appraisal rather than an accounting price.
6. ¶46 IMO (2020). *Fourth IMO Greenhouse Gas Study 2020*. London: International Maritime Organization.