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Global Ocean Accounts Partnership

Technical Guidance on Ocean Accounting for Sustainable Development

For questions and feedback, please contact:
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Abbreviations and acronyms

4IR	Fourth Industrial Revolution
ABNJ	Areas Beyond National Jurisdictions
AIS	Automated Identification System
AIT	Asian Institute of Technology
APRU	Association of Pacific Rim Universities
ARD	Analysis Ready Datasets

ASEAN	Association of Southeast Asian Nations
ASFA	Aquatic Sciences and Fisheries
BSU	Basic Spatial Unit (see Glossary)
CBD	The Convention on Biological Diversity
CBiCS	Combined Biotope Classification Scheme
CBSU	Coastal Basic Spatial Unit
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CEOS	Committee on Earth Observation Satellites
CICES	The Common International Classification of Ecosystem Services (see Glossary)
CMECS	Coastal and Marine Ecological Classification Standard (see Glossary)
CMU	Coastal Marine Units (see Glossary)
COP	Conference of the Parties
CWP	Coordinating Working Party on Fishery Statistics
DIAS	Data Information and Access Services
DON	Dissolved organic nitrogen
DPSIR	Drivers, Pressures, State, Impact and Response
DRSF	Disaster-Related Statistics Framework
EA	Ecosystem Asset
EAA	Ecosystem Accounting Area

EBVs	Essential Biodiversity Variables
ECVs	Essential Climate Variables
eEOVs	Ecosystem Essential Ocean Variables
EEZ	Exclusive Economic Zone
EMUs	Ecosystem Marine Units (see Glossary)
ENGOs	Environmental Non-governmental Organizations
EOVs	Essential Ocean Variables
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
ETs	Ecosystem Types
EVCs	Ecological Vegetation Classes
EWC-Stat	European Waste Classification for Statistics
FAO	Food and Agriculture Organization of the United Nations
FDES	Framework for the Development of Environment Statistics
FIGIS	Fisheries Global Information System
FIRMS	Fisheries and Resources Monitoring System
FOO	Framework on Ocean Observing
GDP	Gross Domestic Product
GEBCO	General Bathymetric Chart of the Oceans
GEE	Google Earth Engine

GEO BON	Group on Earth Observations Biodiversity Observation Network
GEO	Group on Earth Observation
GEP	Gross Ecosystem Product (see Glossary)
GET	Global Ecosystem Typology
GHGs	Greenhouse Gases
GIS	Geographic Information System
GO	Gross Output
GOAP	Global Ocean Accounts Partnership
GOOS	Global Ocean Observing System
GVA	Gross Value Added
HIES	Household Income and Expenditure Surveys
IAEG-SDGs	Inter-agency and Expert Group on SDG Indicators
ICEP	Index of Coastal Eutrophication
ICZM	Integrated Coastal Zone Management
IDEEA	Institute for Development of Environmental-Economic Accounting
IGOs	Intergovernmental organisations
IIED	International Institute for Environment and Development
IMO	International Maritime Organisation
IOC	Intergovernmental Oceanographic Commission

IPCC	Intergovernmental Panel on Climate Change
IPOA-IUU	The 2001 International Plan of Action to Prevent, Deter, and Eliminate Illegal, Unreported and Unregulated Fishing
ISIC	The International Standard Industrial Classification
IUCN	International Union for Conservation of Nature
IUU	Illegal, Unreported and Unregulated
JNCC	The UK Joint Nature Conservation Committee
JNCC-EUNIS	The Joint Nature Conservation Committee – European Nature Information System
LME	Large Marine Ecosystems (see Glossary)
MBON	Marine Biodiversity Observation Network
MBSU	Marine Basic Spatial Unit
MEOW	Marine Ecosystems of the World (see Glossary)
MPA	Marine Protected Area
MSDI	Marine Spatial Data Infrastructure (see Glossary)
MSP	Marine Spatial Planning
NOAA	US National Oceanic and Atmospheric Administration
NPV	Net Present Value
NSDI	National Spatial Data Infrastructure (see Glossary)
NSO	National Statistical Office
NSS	National Statistical System

OECD	Organisation for Economic Co-operation and Development
PEAF	The Poverty Environment Accounting Framework
PEMSEA	Partnership in Environmental Management for the Seas of East Asia
PEN	Poverty-environment-nexus
PON	Particulate Organic Nitrogen
PSUT	Physical Supply and Use Tables (see Glossary)
RFMOs	Regional Fishing Management Organizations
SDGs	Sustainable Development Goals (2030 Agenda for Sustainable Development)
SEEA	System of Environmental-Economic Accounting
SEEA–AFF	SEEA Agriculture, Forestry and Fisheries
SEEA–CF	SEEA Central Framework
SEEA–EEA	SEEA Experimental Ecosystem Accounting
SNA	System of National Accounts
SOLSTICE–WIO	Sustainable Oceans, Livelihoods, and food Security Through Increased Capacity in Ecosystem research in the Western Indian Ocean
SST	Sea Surface Temperature
TBSUs	Terrestrial Basic Spatial Units
TEEB	The Economics of Ecosystems and Biodiversity
TSA	Tourism Satellite Accounts

UNCEEA	UN Committee of Experts on Environmental-Economic Accounting
UNCLOS/ LOSC	United Nations Convention on the Law of the Sea
UNECE-CES	UN Economic Commission for Europe, Conference of European Statisticians
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNISDR	UN International Strategy for Disaster Reduction
UNITAR	United Nations Institute for Training and Research
UNSC	UN Statistical Commission
UNSD	UN Statistics Division
UNSW	University of New South Wales
VMS	Vessel monitoring system
WTP	Willingness to Pay

Preface and Acknowledgements

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Preface

Purpose of this document

- This document describes a statistical framework for measuring the ocean, its importance to people and what people are doing to change it. The document provides some guidance on how to use the framework and what to do with the results. The framework is based on the principle that information is more powerful when it can be reliably combined with other information. Measuring one ecosystem in one location is useful, but if we have the same measures for many ecosystems, we can set priorities about which are the most important to protect or to rehabilitate so that we may retain or enhance their long-term values to society. To combine information from different sources, they must be either collected according to a shared measurement framework or converted to one to be consistent. This document provides a starting point for such a measurement framework.
- This document is intended to be relevant to different audiences, including but not limited to policy experts, scientists, and statisticians. The intent is to provide a common measurement framework that demonstrates how scientific information can be integrated using environmental-economic and other complementary approaches to address national policy priorities.

Importance of the ocean

- There is much agreement that the ocean is important and threatened. Unless we have coherent measures, we will never know *how important* and *how threatened*. From fisheries to marine-based tourism, our ocean is a vital source of livelihood, employment, nutrition and economic growth and it is essential in balancing our climate. Marine and coastal ecosystems are the first line of defence from ocean storms, coastal erosion, sea level rise and saltwater inundation and they are among the richest sources of biodiversity on our blue planet. Yet, rampant marine pollution, ocean acidification and warming, destructive fishing practices, unsustainable or unregulated extraction of marine resources, unsustainable trade and transport, development and unplanned urbanisation, and inadequate coastal and marine governance threaten the health of our ocean and its capacity to nurture sustainable development of, for example, consumptive fisheries and non-consumptive marine-based tourism.

Global commitment to sustainable development of the ocean

- The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (**SDGs**), which are an urgent call for action by all countries—developed and developing—in a global partnership. They recognise that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth—all while tackling climate change and working to preserve our oceans and forests.
- SDG 14 is established "Conserve and sustainably use the oceans, seas and marine resources for sustainable development". How we manage the ocean is also implied in several other SDGs relating to poverty, food, equality, economic growth, disaster risk, sustainable consumption and production, climate change and terrestrial ecosystems. This framework addresses many of these targets and related indicators. It does so by providing guidance on integrating ocean-relevant data, including data on the state of the ocean, our use of the ocean, our impact on the ocean, its impact on us and what we're doing for ocean protection.

The need for partnerships

- This document represents the contribution of more than 120 statisticians, scientists and governance experts from governments, international organisations, universities, the private sector, and research institutes. It addresses SDG 17, which calls for strengthening the means of implementation and revitalization of global partnerships for sustainable development, by encouraging partnerships (e.g., Global Ocean Accounts Partnership) to focus on the global issue of sustainable management of the ocean. No single organisation has the mandate or the influence to improve how we change, benefit from or protect the ocean. It requires collaboration across levels, countries, disciplines, and sectors.

Commitment to implementing the framework

- This document is only the starting point for a comprehensive statistical framework that needs to be tested and expanded. Several collaborators are working with countries on pilot studies and have committed to integrate the framework into their research and their results and experiences into the framework. Feedback from piloting and research will strengthen the framework over time, so that it can be proposed as part of an international statistical standard.

The role of partners

- The Global Ocean Accounts Partnership represents a commitment to improving, harmonising, and applying ocean-related data in accordance with international standards and in keeping with the 2030 Agenda for Sustainable Development. The Secretariat for the Partnership is hosted by the Global Water Institute at the University of New South Wales. The UN Economic and Social Commission for Asia and the Pacific (ESCAP) is a founding partner.
- Several UN agencies have contributed to the document and are participating in pilot studies. ESCAP initiated the first Asia and the Pacific Regional Expert Workshop on Ocean Accounts in August of 2018. During 2019, it supported pilot studies in Asia and the Pacific (China, Indonesia, Malaysia, Samoa, Thailand, Vanuatu, and Viet Nam). ESCAP continues to lead on statistical development of the framework.

Contribution to the SEEA Revision

- The UN Statistical Commission (**UNSC**) had requested ESCAP and UN Environment to take the lead in developing guidance for ocean statistics. This document will also provide input and learn from the revision of the System of Environmental Economic Accounting (**SEEA**) Ecosystem Accounting for 2020.

Overview of the framework and document

- The Ocean Accounts Framework adapts two international statistical standards: the System of National Accounts (SNA) and the System of Environmental Economic Accounting (SEEA). The SNA provides a set of recommendations on how to compile monetary measures of economic activity, including a set of coherent, consistent and integrated macroeconomic accounts. It also provides and overview of economic processes, recording how production is distributed among consumers, businesses, government and foreign nations. SNA accounts are one of the fundamental building blocks of macroeconomic statistics forming a basis for economic analysis and policy formulation.
- The SEEA provides a framework that integrates physical environmental data with monetary data from the SNA, to provide a more comprehensive and multipurpose view of interrelationships between the economy and the environment, and the stocks and changes in stocks of environmental assets, as they bring benefits to humanity. The SEEA contains internationally agreed concepts, definitions, classifications accounting rules and tables for producing internationally comparable statistics and accounts, which are interoperable with the SNA. The SEEA can be applied not only to data on fish stocks, but also to sources of land-based pollutants and the value of ecosystem services such as coastal protection and recreation. The Ocean Accounts Framework is based on the principles, components, and classifications of the SEEA and extends them, where necessary, to better apply to the ocean.
- The current scope of the Ocean Accounts Framework is to support the compilation of spatially detailed national-level accounts covering maritime zones subject to sovereignty or national jurisdiction, namely: internal waters, the territorial sea and contiguous zone, archipelagic waters, the exclusive economic zone (EEZ), and/or the continental shelf claims. This scope can also include particular areas within a maritime zone such as a particular bay, province, or protected area within a territorial sea. However, the framework is also applicable to the compilation of global accounts, recognizing some conceptual challenges in accounting for activities in areas beyond national jurisdiction (ABNJ).
- This document is divided into five main sections:

Introduction to Ocean Accounts	**This section introduces the components of the Ocean Accounts Framework, including scientific and statistical foundations.**
Structure of Ocean Accounts	This section links the components to their foundations in existing statistical frameworks and describes the recommended adaptations and extensions.
Process guidance for compilation of Ocean Accounts	This section serves as a “Quick Start Guide” describes the recommended process for implementing Ocean Accounts, including setting priorities, establishing a shared spatial framework among stakeholders and compiling data.
Use and maintenance of Ocean Accounts	This section suggests other considerations including producing indicators, data sources, policy and governance use cases, research use cases, and enabling factors such as institutional, regulatory and legal frameworks.

Introduction to Ocean Accounts	**This section introduces the components of the Ocean Accounts Framework, including scientific and statistical foundations.**
Research agenda for ocean accounting	This section describes in more detail the areas in which more work is required, such as establishing agreement on spatial units, ecosystem classifications, ecosystem services classification, valuation approaches, application of modelling and remote sensing, and new indicator development.

Areas of future work

- This Guidance is a work in progress, with ongoing efforts to develop the concepts and methodologies described within this document. For an extensive list of research questions, the reader is directed to **5. Research agenda for ocean accounting** and **Appendix 6.8**. Testing of various aspects of ocean accounting, the development of concepts, methodologies, and account structure are described below. Many of the issues described are currently informing, or will benefit from, the SEEA Ecosystems revisions process.
- Future ocean accounts pilot studies are encouraged to test the following:
    - A conceptual framework and classification of characteristic economic activities to support Ocean Economy Satellite Accounting.
    - Global data sources (e.g., global shorelines, bathymetry) for national applications.
    - The size and shape of spatial units for near-shore and offshore areas.
    - The IUCN Global Ecosystem Typology against national and international classifications.
    - 3-dimensional (volume) spatial frameworks, consistent with area-based (2-dimensional) accounting.
    - Scope boundaries of ocean accounts, considering jurisdictional and administrative boundaries.
- Several concepts and classifications are also under development, where a synthesis of existing research is being conducted for:
    - Linking ecosystem processes with ecosystem services classification,
    - Linking ecosystem condition to ecosystem service provisioning,
    - The monetary valuation of ecosystem assets and flows,
    - Allocating the wealth of corporations, households, and governments to the ocean,
    - Disaggregation of different social group beneficiaries, with reference to marginalised groups recognised in the 2030 Agenda for Sustainable Development,
    - Compiling and documenting policy use cases for ocean accounts.
- With regards to the framework of ocean accounts, the following areas are under development:
    - The extension of SNA 2008 to include produced capital (e.g., ports and harbours) in asset accounts,
    - The inclusion of human capital (e.g., ocean knowledge and experience) within ocean wealth accounts, related to measures of cultural ecosystem services,
    - Developing a comprehensive view of monetary asset accounts, that includes the future flows of SNA and non-SNA benefits,
    - The 'Combined presentation' of assets, conditions and flows with spatial and sectoral disaggregation.,
    - Placing the ocean economy within the context of the whole economy, beyond satellite accounting approaches to derive equivalents of national balance sheet, balance of trade (imports/exports), fixed capital formation, depreciation/depletion, and non-market goods and services.

Implementation and finalisation

- This document will be revised on an ongoing basis throughout 2021. The Global Dialogue on Ocean Accounting (Sydney, November 12–15, 2019) reviewed the results of the pilot projects, results from consultations on this document, and recent advances in ocean accounting. Further, we hope to maintain

and expand the expert group into the foreseeable future to continue to test, expand and implement the Ocean Accounts Framework on an enduring basis.
- We encourage feedback on this document from everyone interested in sustainable management of the ocean, including but not limited to:

Scientists (in the broadest sense)	**Are encouraged to test the framework and address the research agenda in their research. Do the concepts, classifications and methods work for you? If not, how would you modify them? *Suggested reading:* Introduction to Ocean Accounts → Structure of Ocean Accounts → Research agenda for ocean accounting**
Statisticians	Are encouraged to review the framework in terms of producing official statistics. Does it fit your user needs for nationally relevant statistics on the ocean? If not, how could the framework or document be improved? *Suggested reading:* **Introduction to Ocean Accounts → Structure of Ocean Accounts → Process guidance for compilation of Ocean Accounts → Use and maintenance of Ocean Accounts → Research agenda for ocean accounting**
Multi-stakeholder working groups engaged in ocean management	Are encouraged to conduct pilot studies to test the framework. *Suggested reading:* **Introduction to Ocean Accounts → Process guidance for compilation of Ocean Accounts**
Policy and governance experts, including governance officials	Are encouraged to review the framework in terms of its usefulness in effectively organizing and presenting reliable information you need to make informed decisions. What could be added to make this more useful for your purposes? *Suggested reading* → **Introduction to Ocean Accounts → Use and maintenance of Ocean Accounts**

- Please submit comments, questions and suggestions to the Global Ocean Accounts Partnership Secretariat (info@oceanaccounts.org). A comment form is provided at the GOAP website.

Acknowledgements

Partnership and international commitments

- This Guidance is the principal knowledge product of an ongoing global collaboration process, referred to hereafter as the Global Ocean Accounts Partnership (**GOAP**). The GOAP brings together diverse member institutions who have a common interest to ensure that the values and benefits of oceans are recognized and accounted for in decision-making about social and economic development. Membership of the Partnership is open to national governments, intergovernmental institutions, inclusive representative bodies for the private sector, and research-intensive institutions that have been granted formal not-for-profit status in their country of origin. Members make a mutual non-contractual commitment to common Partnership Terms of Reference.
- The Global Ocean Accounts Partnership was launched by the United Nations (**UN**) Economic and Social Commission for Asia and the Pacific (**ESCAP**) on behalf of the United Nations in response to the following international commitments:

  - SDG 14 and the ten associated Targets (see **Indicators for sustainable development**) in the 2030 Agenda for Sustainable Development (**2030 Agenda**), calling on all countries and stakeholders to conserve and sustainably use the oceans, seas and marine resources for sustainable development.
  - SDG Target 15.9, calling on all countries and stakeholders, by 2020, to integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.
  - SDG Target 17.19, calling on all countries and stakeholders, by 2030, to build on existing initiatives to develop measurements of progress on sustainable development that complement Gross Domestic Product, and support statistical capacity-building in developing countries.
  - UN General Assembly Resolution 71/312 entitled *Our Ocean, our future: a call for action*, which *inter alia* stresses (1) the importance of enhancing understanding of the health and role of our ocean and the stressors on its ecosystems, including through assessments on the state of the ocean, based on science and traditional knowledge systems, and (2) the need to further increase marine scientific research to inform and support decision-making, and to promote knowledge hubs and networks to enhance the sharing of scientific data, best practices and know-how.
  - UN Statistical Commission Decision 49/110, which *inter alia* (1) requested that ocean statistics be integrated in the work of the revision process of the System for Environmental Economic Accounting (SEEA) Experimental Ecosystem Accounting, and (2) encouraged implementation of the SEEA Agriculture, Forestry and Fisheries.
  - ESCAP Resolution E/ESCAP/RES/73/5 encouraging member States to continue to enhance their capacity to sustainably manage the ocean and requests the Secretariat to support current and new regional partnerships for enhancing data and statistical capacities for SDG14 in the region.
  - ESCAP Resolution E/ESCAP/RES/72/6 requesting the Secretariat, inter alia, to strengthen support to member States in their efforts to implement the 2030 Agenda in an integrated approach, inter alia, with analytical products, technical services and capacity building initiatives through knowledge-sharing products and platforms, and to enhance data and statistical capacities.
  - ESCAP Resolution E/ESCAP/RES/72/9 requesting the Secretariat, inter alia, to undertake an assessment of capacity development needs of the countries in Asia and the Pacific for the implementation of SDG14.
- The process to develop this Guidance has comprised the following steps to date:
  - Assessment by ESCAP to gain a better understanding of the capacity development needs in relation to SDG 14 in Asia and the Pacific to help inform ESCAP's work in this area.
  - Preparation of 10 Issue Briefs and associated summary presentations, featuring written contributions from 122 subject matter experts from more than 25 countries. Each Brief discusses a specific aspects of ocean data and statistics, in particular options and challenges concerning the compilation of Ocean Accounts, and the use of these accounts in different governance contexts.
  - The Asia and the Pacific Regional Expert Workshop on Ocean Accounts, hosted by ESCAP in Bangkok from 1–3 August 2018, as the inaugural event of the Global Ocean Accounts Partnership. The purpose of the Workshop was to facilitate a community of practice around standards for ocean statistics, both in the Asia-Pacific region and globally. The 85 participants included experts in ocean statistics, sciences, and policy from national governments and research institutions as well as regional and international organisations.
  - Several countries are engaging with partners to conduct pilot studies of the Ocean Accounts Framework. The principle behind the pilots is to *(1)* understand the statistical requirements and governance context for addressing national (or sub-national) priorities and *(2)* to engage multi-stakeholder working groups to test relevant aspects of the accounts. To date, related pilots have been initiated by Australia, Canada, China, Malaysia, Samoa, Thailand and Viet Nam.
  - The Global Dialogue on Ocean Accounting on 12-15 November 2019 was co-hosted by the University of New South Wales (UNSW), ESCAP and the High-Level Panel for a Sustainable Ocean Economy, supported by the World Bank Blue Economy Program. The 100+ participants at this workshop provided input to this Guidance, provided feedback on seven Ocean Accounts pilots, showcased research and best practices, and made plans for improving connections between ocean data and ocean governance.

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- Michael Bordt (ESCAP), Ben Milligan (University of New South Wales), Kenneth Findlay (Cape Peninsula University of Technology), and Teerapong Praphotjanaporn (ESCAP) served as Coordinating Lead Authors of this Guidance.
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1. Introduction to Ocean Accounts

Table of Contents

1.1 What are Ocean Accounts?

- An Ocean Account is a structured compilation—of consistent and comparable information: maps, data, statistics and indicators—concerning marine and coastal environments, including related social circumstances and economic activity. The general purpose of such accounts is to inform and enable public policy decision-making about oceans, and related analysis and research. The function of these accounts is to provide coherent structures for standardizing often-fragmented data to produce reliable integrated indicators of interest to policy. Dissemination of these indicators can be accomplished through national reports, nationally managed websites, or interactive "dashboards" which allow user querying. Ocean Accounts are distinguishable from other compilations of ocean-related information on the basis that they are:
    - organised by the **Ocean Accounts Framework**, which is designed to enhance the consistency, comparability and coherence of ocean-related maps, data, statistics, and indicators across social, environmental and economic domains.
    - compatible with **relevant international statistical standards and approaches**: including but not limited to the System of National Accounts (SNA), System of Environmental-Economic Accounting (SEEA), and Framework for Development of Environment Statistics (FDES); and
    - compatible with the **Fundamental Principles of Official Statistics**. These Principles were endorsed by the UN General Assembly in January 2014 and are designed as a reference point for ensuring that official statistics are fit-for-purpose given their critical role in: policy decision-making in support of sustainable development; and securing public trust in governance. The Ocean Accounts Framework promotes the application of scientific and international standards, as well as data quality and coherence across multiple frameworks.

- Ocean Accounts are designed to support **coherent and holistic reporting and assessment** of the wide range of social, economic, and environmental conditions related to oceans. This broad perspective is intended to be consistent with the practical information requirements of decision-making to achieve sustainable development — which is defined for the present purposes in general terms as meeting the needs of the present without compromising the ability of future generations to meet their own needs.
- The Ocean Accounts Framework is distinct from related initiatives, largely due to its comprehensive scope and statistical foundations. It can bring coherence, an environmental perspective, and a policy context to the many interpretations of the "ocean economy" and "blue economy" that centres on sustainability and inclusivity. It can provide a coherent, agreed information base for strategic and spatial planning of the ocean and coasts, regulation of ocean-based economic activities and sectors, adaptive management to keep pace with policy cycles, and associated investment decisions. It can also provide impartial evidence to monitor and evaluate ocean-related policies and be used to develop a statistical foundation for monitoring of progress towards international commitments such as the Paris Agreement on Climate Change, Convention on Biological Diversity, and 2030 Agenda for Sustainable Development including the SDGs. Further, it can be used to identify gaps in our knowledge and help focus research on filling those gaps.

1.2 Overview of the Ocean Accounts Framework

- Ocean Accounts are fundamentally a collection of accounts (or modules) that are organised in terms of a conceptual framework. These accounts may be implemented selectively depending on national priorities, data availability and technical capacity. Overall, the framework describes:
  - interactions between the economy and the environment,
  - the stocks (flows) and changes in stocks of environmental assets (natural capital) that provide benefits to people, and
  - social and governance factors affecting and affected by the status and condition of environmental assets and associated benefits.
- The general structure and groups of component tables of the Ocean Accounts Framework are illustrated in **Figure 1** below, and can be summarised as follows:
- **Ocean assets (natural capital):** recording the physical status and condition, and monetary value, of marine and coastal environmental assets (natural capital) including minerals and energy, land and soil, coastal timber, aquatic resources, other biological resources, water, and ecosystems including biodiversity.
- **Flows to economy (supply and use of ocean services, including goods[1]):** recording inputs from marine and coastal environmental assets to the economy, including ocean-related materials (abiotic and biotic), energy, water, and ecosystem services. These inputs can be recorded in terms of physical quantities and monetary value.
- **Flows to environment (residuals including ecosystem impacts):** recording in physical units the outputs from the economy to the ocean environment including: solid waste, air emissions, water emissions, and impacts on ecosystems.
  - **The ocean economy as a contribution to the national economy:** recording the monetary value of production, consumption, accumulation, imports, and exports in economic sectors deemed relevant to the ocean, as well as non-market services in comparison to the economy of a nation. The economy is reflected in the Ocean Accounts as users of ocean services and suppliers of residuals (pollutants) and activities that affect the ocean.
  - **Governance:** recording a range of information (physical status, monetary value, and/or qualitative status) concerning collective decision-making about oceans, and the wider social and governance context in which such decisions are made. Information recorded in governance tables includes the status and/or value of: protection and management of ocean environment; the "environmental" goods and services sector of the ocean economy; relevant taxes and subsidies; applicable laws and regulations; health, poverty and social inclusion; risk and resilience; and ocean-related technologies. Inclusion of health, poverty, and risk management may require a separately identified social account to address inclusivity within the overall account framework.

- **Combined presentation:** recording a “report card” of summary information (physical quantities, monetary value, and/or qualitative status) and indicators concerning the flows of benefits and costs (the latter broadly defined as maintenance and restorations costs, disservices and externalities[2]) between the ocean environment and the economy. This information includes but is not limited to: the share of Gross Value Added / Gross Domestic Product attributable to the ocean economy; ocean resource rents; depletion, degradation and adjusted net savings relevant to oceans; contributions of oceans to human well-being (employment, sense of place) that are not recorded in the SNA; and relevant information concerning health, poverty and social inclusion.
- **National Wealth:** recording summary information (in terms of physical quantities, and/or monetary value) concerning a country’s (or other region’s) **stock of ocean wealth**, including relevant stocks of environmental assets recorded on a SEEA balance sheet; economic/financial assets recorded on an SNA balance sheet; a subset of environmental assets that are defined as “critical” according to agreed criteria; the resource life of environmental assets; and relevant societal assets such as education and health systems.

[1] Ecosystem services, in the past were referred to as “ecosystem goods and services”. For simplicity, the term has been shortened and this convention is maintained in this Guidance. That is “Ocean services” includes “goods”.
[2] These costs are included in the framework in theory, but not dealt with in detail in the current Guidance pending further discussion.

- When compiled on a regular basis, the information recorded in these tables can support a wide variety of decision-making processes in relation to commitment to international imperatives, for example:
- **Strategic development planning:** including formulation of strategies and objectives for sustainable development of the “ocean” or “blue” economy, informed by a holistic accounting of ocean wealth, and associated flows of benefits in relevant sectors.
    - **Management of ocean space:** including the designation and monitoring of protected areas, marine spatial planning (MSP) and integrated coastal zone management (ICZM)[3], and regulatory approvals and conditions for ocean activities and infrastructure, informed by a broad understanding of the current and past extent, condition and value of ocean assets (including ecosystems) and flows of benefits associated with those assets. This will better identify and prioritize marine ecosystems in need of new or continued protection to achieve restoration/recovery and help balance between the equilibrium of an economic and conservation benefit.
    - **Finance and investment:** including the design and allocation of taxes, subsidies and public investment related to oceans, for specific economic sectors, social groups or locations, informed by integrated accounting of previous financial flows and the associated changes in social, environmental or economic conditions.
    - **Ocean analysis, monitoring and assessment:** including impact assessment, strategic impact assessment, and benefit-cost analysis informed and contextualised by the time series of integrated social, economic and environmental information recorded in Ocean Accounts.

[3]Marine spatial planning (MSP) and Integrated Coastal Zone Management (ICZM) aim to coordinate and balance the needs of several types of activity within the same area. These are distinct from other approaches that focus on managing specific sectors or specific areas. (UN Environment, 2018)

Figure 1. General structure of the Ocean Accounts Framework

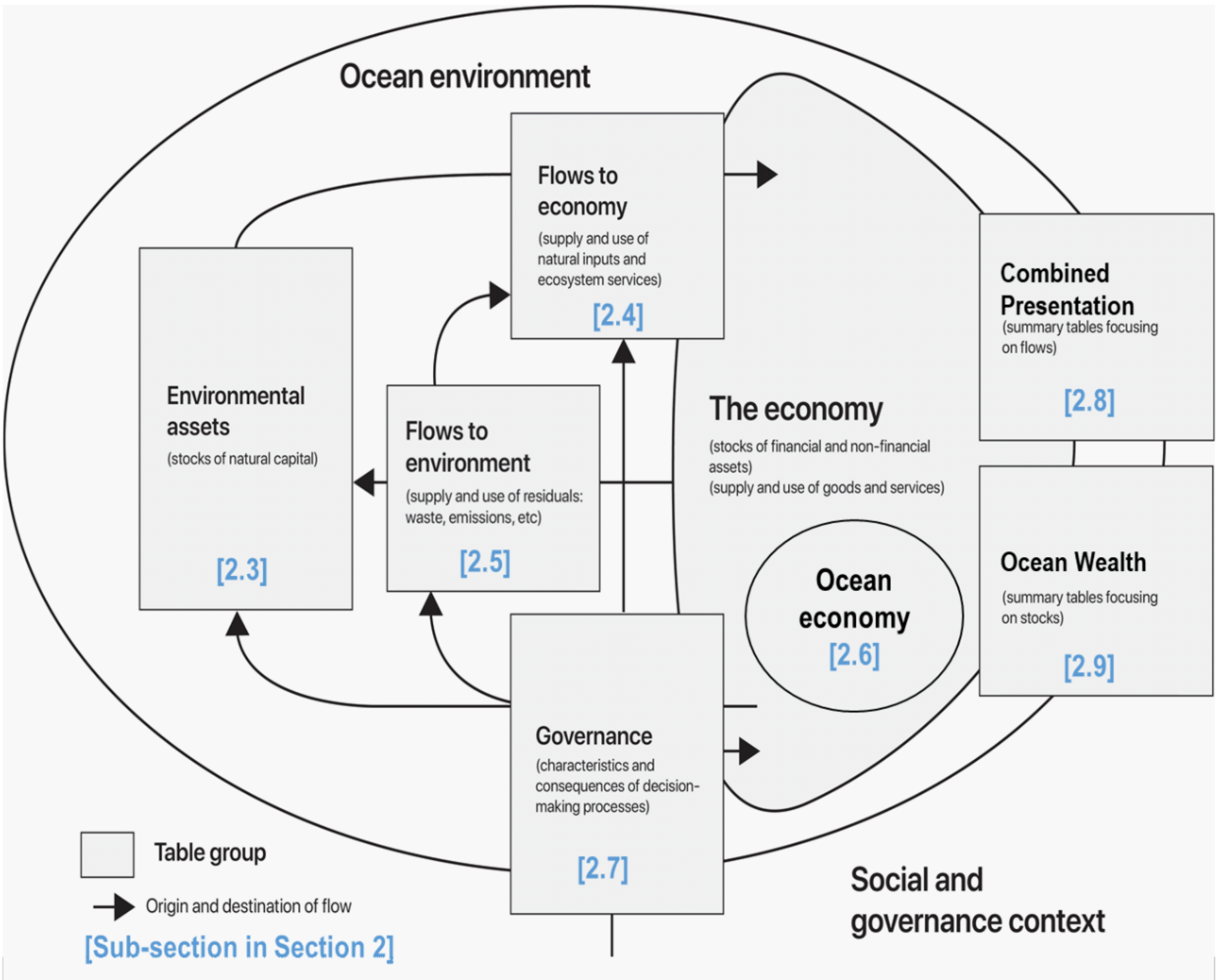


Figure 1. General structure of the Ocean Accounts Framework

- The Ocean Accounts Framework directly incorporates present efforts to advance standard classifications of ecosystems and services which are consistent with the following international frameworks and standards concerning data and statistics:
- **System of National Accounts** **(SNA)** is the international statistical standard that countries use to measure the economy. It produces a well-understood set of macro-economic indicators, including Gross Domestic Product.[1]
    - **The SEEA Central Framework** **(SEEA-CF)** is consistent with and enlarges the scope of the SNA. It measures the contribution of nature to the economy by providing guidance on measuring the physical quantities and monetary values of natural assets (land, water, timber, minerals, energy) in the country, their flows into to the economy (supply), their use in the economy (use), residuals produced from their use and expenditures to mitigate impacts on the environment. The SEEA has been revised twice since its inception in 1992. Over 90 countries in the world have produced one or more SEEA accounts. The most common are water, energy and land.
    - **SEEA Experimental Ecosystem Accounting** **(SEEA-EEA)** adds to the SEEA-CF guidance on measuring ecosystems as integrated assets that provide benefits to people. It includes guidance on measuring

ecosystem extent, their conditions and the services they provide to people. The SEEA-EEA brings coherence to various works on ecosystem services assessment by providing a standard classification of ecosystems and ecosystem services. It suggests a coherent approach to spatial units. It also provides guidance on monetary valuation of ecosystem assets and their services to ensure these measures are coherent with the SNA. The SEEA-EEA applies a broader scope of valuation than the SNA or SEEA-CF. While it provides guidance on measuring the direct contribution of ecosystems to the economy (SNA benefits), it also provides scope for measuring ecosystem services that contribute to long-term ecological integrity (regulation and maintenance services) and a broader set of societal values (cultural services). At least 30 countries have produced SEEA ecosystem accounts. Most begin with establishing agreed maps of ecosystem extent.

  - **National Spatial Data Infrastructure (NSDI)** : Much work on SEEA-CF Land and SEEA Ecosystem Accounts relies on integrating spatial data from multiple sources inside and outside governments. This has led to the general recommendation (United Nations, 2017) that countries establish and apply an NSDI that provides principles and processes for harmonising spatial data. In some countries, the NSDI also encompasses a Marine Spatial Data Infrastructure (MSDI). In others it is limited to terrestrial areas.
  - The **Framework for the Development of Environment Statistics (FDES)**, provides guidance on a core set of environmental indicators that has proven beneficial to inform policy. It is designed to assist all countries in articulating environment statistics programmes by: (i) delineating the scope of environment statistics and identifying its constituents; (ii) contributing to the assessment of data requirements, sources, availability and gaps; (iii) guiding the development of multipurpose data collection processes and databases; and (iv) assisting in coordination and organisation across institutions. Many countries use the FDES to organize statistical publications and integrate themes of indicators, such as energy, into SEEA accounts.
- The Ocean Accounts Framework is also intended to be complementary to the following international statistical frameworks and guidance:
  - The **Sendai Framework for Disaster Risk Reduction** provides several disaster-related definitions, indicators, and priorities for action, and the Disaster-Related Statistical Framework (DRSF) (ESCAP, 2017) provides guidance on measuring disaster risk and impacts, as well as the basic range of disaster-related statistics.
  - **COP 23 Ocean Pathway** has recognized that the ocean is closely linked to climate change concerns. The Intergovernmental Panel on Climate Change (IPCC) provides substantial guidance on the collection and organisation of greenhouse gas emission inventories from anthropogenic sources (IPCC, 2006). The UNECE CES Task Force (UN Economic Commission for Europe) on a set of key climate change-related statistics using the System of Environmental-Economic Accounting has developed a set of related key climate change-related statistics using the SEEA and other statistical frameworks. These indicators cover drivers of climate change, emissions, impacts, mitigation efforts and adaptation activities.
  - UNSD initiated a process to develop a **Global Set of Climate Change Statistics and Indicators**based on a systematic review of country-based practices and close link between global climate change negotiations and reporting on national statistics. At present, the availability of relevant statistics in most countries varies across the five areas: drivers, impacts, vulnerability, mitigation and adaptation
- A comprehensive measurement framework for Ocean Accounts would evolve by connecting to and sharing standards with these existing frameworks. The current framework is a work in progress and the intent is to integrate data consistent with these frameworks, but wherever possible, in a spatially-detailed manner Knowing where assets are and where their condition is good or poor provides an important analytical basis to support planning and decisions on where best to protect, rehabilitate or sustainably exploit ocean resources. Opportunities for further integration and extension are discussed in the **Appendix 6.8 (**Additional Research Questions). For example, by coordinating the disaster risk and climate change communities of practice, implementation of the Ocean Accounts would ensure that similar data are collected only once and shared across these communities. These data include but are not limited to: identifying coastal communities and infrastructure at risk, delineating coastal and marine ecosystems, assessing and valuing economic and ecological losses, tracking ocean conditions and identifying priority mitigation measures.

- For the purposes of this document the term "Ocean" refers to a space that includes "coastal" and "open ocean (pelagic)" areas combined.

1.3 Scientific foundation of Ocean Accounts

- Oceans cover 71% or 361 million square kilometres of the Earth's surface. The average depth of the 20% that has been mapped is about 3.8 kilometres. Maximum depths can exceed 10 kilometres (6.2 miles) in ocean trenches. We know little about what exists on the seafloor, since less that 0.001 percent has been biologically or geologically sampled. The oceans contain 97% of our planet's available water.
- The vastness of the ocean, both in surface area and in depth, and the extent of its unexplored areas, make it distinct from better-known terrestrial and freshwater systems. It embodies cycles and systems that are sometimes separate from and sometimes intimately linked to those on land, freshwater and the atmosphere. To explain the concepts used in the Ocean Accounts, this section reviews the basics of what is known about the ocean, initiatives to measure and it and what remains to be understood.
- In terms of the SEEA, there are many nuances that are explained in this section. Ocean assets, whether aquatic resources (SEEA-CF) or ecosystems (SEEA-EEA) may move in space over time and exist in three dimensions. The services they supply and the beneficiaries that use them are therefore also multi-layered and dynamic. The health of ocean ecosystems is influenced by land-based sources (e.g., runoff from agriculture), marine sources (e.g., fuel spills from marine ships), as well as atmospheric sources (e.g., carbon emissions). These impacts diffuse at different rates depending on currents, winds and tides. This dynamism increases the uncertainty of the already sparse data available. To collaborate with ocean scientists, non-scientists should be familiar with these general concepts.

1.3.1 General concepts

- The Earth's seas can be divided into five major oceans: Pacific, Atlantic, Indian, Arctic and Southern (Antarctic). The Southern Basin is defined based on the unique characteristics of the waters flowing around Antarctica. Each of these may be further divided into basins based on the presence of underwater rises. Basins vary in depth and in their level of geologic activity, as a result of the movement of the underlying **tectonic** plates. Ocean space is also divided into vertical layers, defined by the profile (depth and slope) of the floor and the amount of light that penetrates to that depth. Classification of ocean space therefore needs to consider not just by geographic boundaries, but also by oceanographic boundaries, such as definitive ocean currents, temperature of salinity gradients, or **depth profiles** defined by light regimes (**Figure 2**).

Figure 2. Nutrients fall to light-poor depths, runoff from land and are brought to the surface by currents

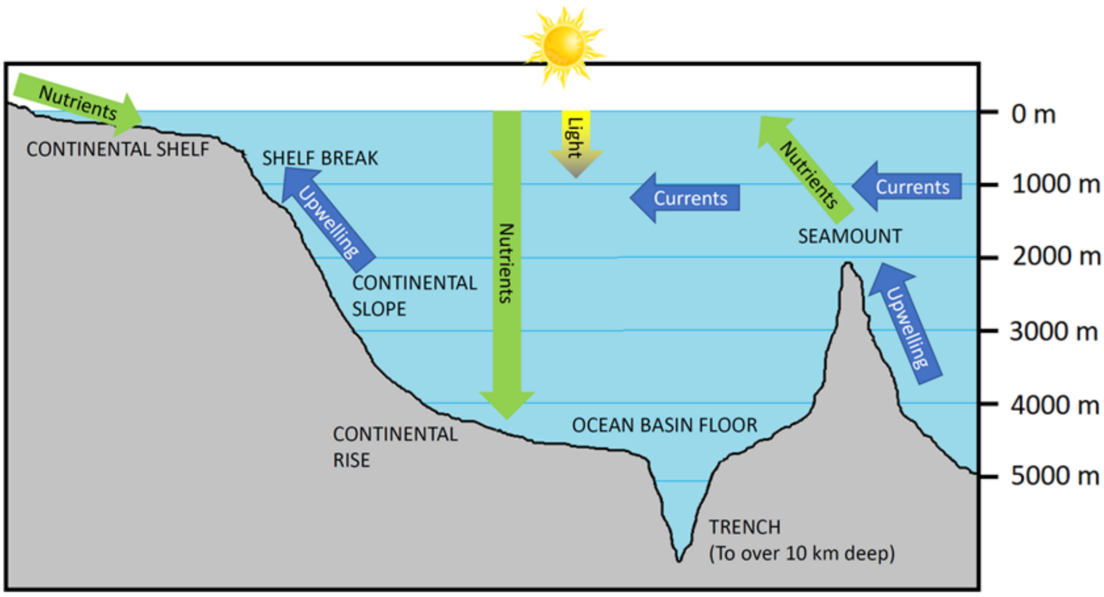


Figure 2. Nutrients fall to light-poor depths, runoff from land and are brought to the surface by currents.

- Ocean **bathymetry** is varied, like terrestrial topography, and can be thought of as an extension of terrestrial and river systems. From the coastal plain to open ocean, the land generally descends underwater, first to the continental shelf, then to the continental slope, next to the continental rise, and finally to the relatively flat area of the ocean basin itself (also known as the **abyssal plain**). The continental shelf is the gently sloping area from the coast to the continental slope, which is a steep drop off (thousands of meters) to the continental rise and the abyssal plain beyond. The width of depth of the shelf, slope, rise, and abyssal plain varies depending on the ocean basin. Submarine canyons may cut into the continental shelf, adding additional physical and habitat complexity. The flat abyssal plain of the ocean basin may be broken up by **trenches** (deeper areas) and **seamounts** (underwater mountains).
- Since ocean water absorbs light, different depths have different amounts of light reaching them. Sunlight penetrates more easily down to about 200 m in depth. This is called the **epipelagic**, **euphotic**, or sunlit zone. Between 200 m and 1 km, in the **mesopelagic**, **disphotic**, or twilight zone, there is a rapid decrease in sunlight penetration. Below 1 km is the **bathypelagic**, midnight, or **aphotic** zone, which receives no sunlight. This interaction of light and depth will impact the potential for photosynthesis and the biotic components (e.g., plankton, fish) that may exist.
- Like sunlight, temperature also generally decreases with depth from the surface, but not at a constant rate. Temperatures in the sunlit zone, because of the action of the sun, wind, and waves will follow trends (with a lag) in the surface temperatures above. Below this sunlit zone the temperature drops off quickly; this **thermocline** is the temperature transition zone between the surface waters and the cooler bathypelagic waters, where temperatures are relatively constant. The thermocline and, therefore, temperature gradient, will vary depending on the season and the location in the global ocean system; for example, an arctic system may have little or no thermocline, with waters at surface and waters at depth at similar temperatures.
- Surface and deep-water currents transfer heat, nutrients and biota around the ocean within complex **ocean circulation patterns**. These play a major role in influencing global climate and the latitudinal distribution of different ecosystems, including terrestrial ones.
- While sunlight and temperature decrease with depth, pressure increases with depth with the weight of seawater pushing down from above. Pressures at depth can be hundreds of times the pressure at the surface. This consequently creates another constraint on biotic components of the system.
- Evaluation of oceans cannot be done independently of consideration of the adjoining coastal areas and habitats. Coastal **estuaries** are important interfaces between terrestrial, freshwater, and marine systems,

supporting organisms such as mangroves, crabs, shellfish, seagrasses, and various fish species, that thrive in the changing tides and mix of freshwater and saltwater. Coral reef and lagoon complexes provide additional habitats and feeding grounds for many and varied marine species, ranging from the corals themselves to sharks to sea turtles to a diverse assemblage of fish species. Estuarine areas are also often densely populated by people given the historic and ongoing value of coastal location for food sources and trade. These concentrations of people have varied and complex relationships with the coastal area as well as the more remote marine areas.

1.3.2 Components of the ocean environment

- Ocean environments are composed of both **abiotic** (non-living) and **biotic** (living) components of coastal and marine environments. The interaction of these components plays an important role in determining the dynamics in an area of the ocean.
- Abiotic components of the ocean environment include minerals and nutrients, water, sunlight, and gasses. More broadly, other physical features like waves, currents, temperature, and pressure may also be considered abiotic conditions. and are important in several economic activities such as the generation of renewable energy. The quantity and quality of abiotic factors can influence the biotic components through physical, chemical, and biological processes.
- Biotic components of the ocean encompass the multitude of plants and animals, from microscopic plankton to **megafauna** whales, that interact with and utilize the abiotic components in different ways.
- These components interact in systems (geo-physical, atmospheric, and ecological), which are key to understanding oceans for accounting for stocks and flows. These systems also interact with the human social and economic system.

1.3.3 Geo-physical and atmospheric systems

- Understanding global ocean **circulation patterns** and the combination of surface and deep-water currents is essential to understanding ocean dynamics. Surface currents transfer heat from the equator to the poles. Deep water currents move dissolved gases and nutrients from the surface to deep waters. Currents support the food web by bringing nutrients (like nitrogen and phosphorus) and food supply to locations that otherwise would be nutrient-limited. They also help move aquatic life around.
- **Surface circulation patterns**, which generally move the top 100 meters or so of the ocean, are driven by winds, so they tend to follow the direction of trade winds until they intersect with a continent. An interesting feature of surface circulation patterns is that water in the western side of a current system (e.g., in the Gulf Stream) tend to move faster and are narrower than in the eastern side of currents.[4]
- **Thermohaline circulation,** driven by temperature and salinity differences leading to higher density of surface waters at the poles, moves masses of water vertically and then horizontally at depth across the global ocean.[5] It takes about 500-1000 years for water to complete the movement in thermohaline circulation since it is much slower than surface currents. These currents pull oxygen, CO_2, and nutrients down with them to be redistributed to deep waters and around the globe. When these currents encounter continental margins or (in a more localized manner) **seamounts**, this causes **upwelling**, which brings the deeper, colder, nutrient-rich water to the surface. Upwelling also arises from wind driven processes resulting in Ekman transport of deep waters to the surface. Nutrient-rich waters when upwelled into the photic zone allow for enhanced primary productivity leading to highly productive areas.For example, upwelling occurs on the western coast of South America, where this process supports important fishing areas.
- **Chemical cycles** are also important for the marine environment, because of the transformation of compounds into forms that are available for uptake by phytoplankton (microscopic marine algae, the base of the food web). Nitrogen gas is **fixed** (converted to biologically useable form) by certain species of photosynthetic and non-photosynthetic bacteria. For example, the ammonium ion is a more accessible form of nutrient and is taken up by aquatic microbes, such as phytoplankton or microalgae. Nitrification also occurs to convert ammonium to nitrate, which is also one of the more common forms of nitrogen taken up

by marine microbes. The organisms take up the nitrogen and it therefore becomes either particulate organic nitrogen (PON) or dissolved organic nitrogen (DON), which can then be re-mineralised back into ammonium.
- Carbon dioxide (CO_2) is taken up by the oceans by diffusion or through the fixation of carbon by phytoplankton. The diffusion of CO_2 into water has important impacts on ocean chemistry. After forming a weak acid with plentiful H_20, this compound dissociates into carbonate, bicarbonate and hydrogen ions. The increase in hydrogen ions decrease the pH of the ocean and reduce the available supply of carbonate ions. Marine creatures, such as molluscs, corals, and crustaceans, make use of the calcium and carbonate ions to form shell structures.

[4] Below about 100 m, the water is denser and generally does not mix with the surface, other than by vertical circulation at the poles and upwelling areas. This barrier is called the **pycnocline**. Intermediate and deep currents are driven by this vertical circulation.
[5] In the Arctic and Antarctic, the colder waters sink and slowly flow back towards the equator, where mixing with warmer waters eventually enables the water to rise back to the surface.

1.3.4 Ecological systems

- The Convention on Biological Diversity (CBD) defines an **ecosystem** as a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.[6] Ocean ecosystems and their conditions can be more complex and dynamic than terrestrial ones. There is no accepted standard classification of ocean ecosystems or agreed measures of their condition. **Environmental asset accounts** suggests starting points for measuring these and **Earth Observation Data** recommends a core set of ocean statistics that captures the complexity and dynamism of the ocean.
- Organisms fulfil different roles within the ecological system. A useful way of grouping species is by **trophic level**, their position in the food web. At the base of the food web are the producers, the microscopic plants, or phytoplankton, seagrass, and algae that, like most plants, convert sunlight and CO_2 into carbohydrates and oxygen by photosynthesis. The primary consumers, such as zooplankton and herbivorous forage fish, operate at the next level of the trophic structure. Forage fish, also known as prey fish, likewise provide a meal for higher-level predatory fish and birds, which eventually provide a meal, and energy, to top predators. The exact structure and number of levels will vary based on the location and the categorization approach used. Since energy is lost at each step in the trophic structure, there are fewer top predators than primary consumers and fewer primary consumers than producers. Bacteria and marine fungi engage in important functions, such as nutrient cycling and decomposition of organic matter. Marine food webs can be quite extensive and cover large distances. Great White Sharks are top predators and are known to travel over 4,000 km in an open ocean. Humpback whales make annual migrations of up to 6000 km between breeding and feeding grounds.
- The type of life present in a given area of the ocean reflects the interaction of the ecological system with geophysical and atmospheric systems and constraints related to the penetration of light to ocean depths. Most of the ocean life with which we are familiar, as well as the important phytoplankton base of the food web, lives in the sunlit or epipelagic zone. The deeper waters of the twilight and midnight zones have less well-known species and develop adaptations to lower light levels and higher pressures. While many organisms are restricted to narrow depth ranges, others move within and between zones for both feeding and to escape from predation. When organisms in the upper zones die, their remains fall to deeper waters, where they provide nutrients to those living below.
- Apart from light and its role in ecological systems, there are also clear impacts of the chemical and nutrient cycles noted above on the ecological system. CO_2 that is fixed into carbon by phytoplankton enters the food web described above, where it also has the potential to support higher trophic level species. Increased nutrient availability through conversion into bioavailable forms and upwelling can fuel phytoplankton growth and support a spatially complex food-web system. Currents also distribute seeds, eggs, larvae, and adults throughout the ocean.

- The interaction of the topography and oceanography with ecological systems can create local "hot spot" areas of high biodiversity. Seamounts, guyouts, and ridges in deep-sea environments and other upwelling areas along coasts, can provide a habitat for clustering of plants and animals (e.g., fish, mussels, corals, sponges). Their raised topography intersecting with ocean currents provides immobile organisms with a ready supply of passing food and nutrients.

> [6] CBD definition of biodiversity from Article 2 of the Convention: "variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."

1.3.5 Ocean, society, and economy

- Coasts are home to a large proportion of the global population. Estimates suggest that 40% of the world's population lives within 100 km of the coast and this number is expected to increase in the coming decades. This average hides differences in coastal population density across countries: by some estimates, coastal population densities are three times the world average (Small and Nicholls, 2003). This density brings advantages to coastal inhabitants including to access to coastal and marine resources, recreation, and transport, although there are but also disadvantages related to sea level rise risk, and exposure to coastal storms.
- Major components of the ocean market economy include capture and recreational fisheries, aquaculture, use of waters for shipping/transport, offshore energy (both renewable and non-renewable), mineral extraction, coastal recreation and tourism, and coastal property. Offshore renewable energy development (e.g., wind farms) has gained increasing traction over recent years, as has exploitation of marine mineral and genetic resources. Coastal and marine tourism is projected to continue to increase over time, which will likely increase pressures (demand for land, water, and energy as well as impacts of pollutants and ecosystem damage) on ocean areas.
- Coastal and marine environments also provide non-market benefits, such as the waste mediation, carbon sequestration, non-market recreation (such as the enjoyment of walking along the beach) and the knowledge that ocean ecosystems and their iconic species are healthy and conserved. These are rarely included in overall estimates of the ocean economy but should not be ignored. Incorporating these broader values is, however, one of the objectives of ecosystem accounting.
- The concept of the **Anthropocene**, or the era of humans as the driving force of changes in our planet's climate and environment, requires a consideration of socio-ecological systems and their feedback loops. The ocean environment is not immune to the significant role of the human population in modifying its structure and function. Unsustainable extraction (including IUU fishing), increasing pollution, habitat destruction and anthropogenic stressors (e.g., eutrophication, warming, and acidification) are examples of the human-induced alterations of the ocean systems. An accounting structure will assist in tracking changes resulting from these pressures and making appropriate plans to manage them.

1.3.6 Initiatives to measure and assess the ocean

- Humans have studied the ocean realm for centuries. Recent advances in ocean research technologies have centred on Fourth Industrial Revolution (4IR) and are changing how ocean science collects and analyses data. Improvements in scientific research methodologies are being unlocked through new ocean robotics, remote sensing, big data, analytics and modelling, automated image analysis, genomics, machine learning and automated analytic technologies.
- Given the multiple interacting systems of the ocean and its complex interconnections, integrated assessment has gained increasing traction over the past several decades. These assessments generally gather information on a set of indicators (of both the natural and human systems), their real and/or

projected changes, and may also include an evaluation of the drivers of changes of the indicators (using a DPSIR framework). Below are some examples of assessment approaches that included the ocean system.

- In the early 2000s, the Millennium Ecosystem Assessment convened experts from around the globe to evaluate the status and trends of ecosystems, including coastal and marine, and the implications for human well-being. Findings from the synthesis report included: rapid and extensive change of ecosystems by people; substantial and largely irreversible loss in the diversity of life on Earth; substantial net gains in human well-being and economic development, but at the growing cost through degradation of many ecosystem services; and increased risk of non-linear changes, and the exacerbation of poverty for some groups of people. These problems, unless addressed, will substantially diminish the benefits that future generations obtain from ecosystems—especially coastal and marine ecosystems.
- The UN convened a group of experts to conduct the first World Ocean Assessment; the final report was released in 2015. Key findings from the assessment include the substantial threat from climate change for oceans (e.g., increased deoxygenation, increased acidification), the determination that the exploitation of living marine resources is not sustainable in many locations, and increasing pressures on biodiversity, particularly in places where biodiversity hot spots and humans intersect. The report also found that there is increasing demand and potential conflict in the use of ocean space and that the increasing population and use of agriculture is increasing the waste flows into the coastal and ocean environment. The report (Chapter 9) highlighted the potential of the SEEA to harmonize data and to link ocean science to economic decision making.
- In 2019, the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES) published an assessment[7] of the status of global biodiversity and ecosystem services. Their key findings indicated that direct exploitation, mainly through fishing, had the largest relative impact on nature in marine systems and that climate change is "exacerbating the impact of other drivers on nature and well-being". They also highlighted the intersection of loss of nature and its benefits with the incidence of poverty. The International Oceanographic Commission of the United National Educational, Scientific and Cultural Organization (IOC-UNESCO) coordinates programmes in ocean-related research, services, and capacity building. This role includes coordinating the UN Decade of Ocean Science for Sustainable Development (2021-2030). Among its programmes are the coordination of the Global Ocean Observation System (GOOS) and several other scientific workstreams including blue carbon, acidification, the effects of climate change and deoxygenation. Data and information are facilitated though two specialized bodies: The Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM; currently in the process of update for UN decade needs) and the Intergovernmental Oceanographic Data and Information Exchange (IODE). Of particular interest to ocean accounting, IODE maintains several relevant databases and other tools including: the World Ocean Database (WOD), the Ocean Biogeographic Information System (OBIS), the Ocean Data Information System (ODIS) as well as an inventory of ocean experts and publications. The General Bathymetric Chart of the Oceans (GEBCO) operates under joint supervision of the International Hydrographic Organization (IHO) and IOC-UNESCO. GEBCO conducts several mapping projects regionally and globally, including Seabed 2030, a joint operation with the Nippon Foundation to map 100% of the ocean floor by 2030.
- Many localized integrated ecosystem assessments have also been conducted, such as those conducted by NOAA on the California Current system, the Gulf of Mexico, the Northeast Shelf, and the Alaska Complex, by UN Environment for the Mediterranean, Canada for its marine coasts and Australia for the Great Barrier Reef. A common thread among these assessments is that the rate of change is increasing, and that research is required to fill data and knowledge gaps.
- The above synopsis identifies that the ocean is changing, human use of the ocean is changing and the way we measure the ocean is changing. Tracking these changes and linking them to societal value systems provides an important understanding if of the impacts of these changes on ocean assets and the resultant flows of goods and services from such assets. There are a number of different ocean "health" indices by which the condition of systems can be assessed, including for example the Ocean Health Index, and the IUCN Red List of Ecosystems. These along with NOAA - developed indicators targeted aimed at tracking of ocean asset changes can assist in informing important condition indicators for ocean asset accounts.

- Looking to the future, the IPCC recently released an assessment of the "Ocean and Cryosphere in a Changing Climate," which used new data to demonstrate the acceleration of ocean warming, sea level rise and acidification and likely future scenarios.
- More broadly, TEEB's (The Economics of Ecosystems and Biodiversity) planned initiative for Oceans and Coasts "will seek to draw attention to the economic benefits of ocean and coastal biodiversity and healthy ecosystems and emphasize the unrealized benefits of preserved and enhanced whole ecosystem structures, functions and processes to the well-being of humans and nature".
- Australia's Reef Restoration and Adaptation Program funded by the Australian Government for over 50 million to combine novel approaches in environmental engineering and social and environmental economics to combat climate change on the Great Barrier Reef. This is the first large-scale government-funded interdisciplinary project to simultaneously conduct socio-economic and scientific research on the same ecosystem over adequate spatio-temporal scales to monitor and react to the effects of climate change.

1.3.7 Key scientific challenges

- The ocean's vastness in surface area and depth, coupled with the multiple dynamic interactions discussed above, makes it a challenge for advancing scientific understanding. There are several ways we can make progress in advancing our understanding of the ocean system. There are few global data sets that extend below the ocean's surface, although the ARGO program and its recent extension to include measurement of phytoplankton is gradually changing this. Additionally, There is growing global coordination to consistently measure coastal habitats including mangroves, seagrass, macroalgae, and coral reefs as Essential Ocean Variables under GOOS and essential to many ecosystem services, including blue carbon, however, there is relatively limited data on how changes in ecosystem extent and condition measures (e.g., area of mangrove habitat, water temperature) will lead to changes in biomass of more mobile aquatic organisms.
- Key to better scientific understanding of the ocean will be addressing data gaps. While there are global data sets that can provide information on certain indicators like temperature and chlorophyll *a* concentrations, less data are available at smaller scales, and there are few global data sets that extend below the ocean's surface. Fisheries data are available on a global level for certain commercial species, but these data are not tracked in a consistent manner and data on species interactions remain limited. There is also relatively limited data on how changes in ecosystem extent and condition measures (e.g., area of mangrove habitat, water temperature) will lead to changes in biomass of aquatic organisms. These latter relationships would be important for understanding how identified trends in accounting system components may be used to project potential future changes in the ocean system.
- Data and knowledge gaps also limit the application of social sciences, including economics, to managing our collective impacts on the ocean. For example, studies are only recently emerging on the links between ecosystem services and the well-being of diverse beneficiaries (for example, Horcea-Milcu et al., 2016; See **Health, poverty and social inclusion**). The SEEA Ecosystems revision process has initiated the development of new approaches to measuring asset values that include ocean ecosystems. These approaches will be included in subsequent revisions of this technical guidance. Conducting Ocean Economy Satellite Accounting (OESA) is dependent on the level of detail available in a country's SNA. Countries with the greatest dependence on ocean assets have the least detailed SNA.
- Since the oceans involve an interaction of geo-physical, ecological, and human systems, there is an ongoing and pressing need for connecting knowledge across disciplines, particularly by developing a common accounting framework. While the accounting system alone will not provide the answers to research questions (i.e., analysis will be needed), a collaborative, interdisciplinary approach assures that an appropriate and inclusive set of metrics or indicators are being tracked consistently and coherently. Present examples include the UN Decade for Ecosystem Restoration which aims to prevent, halt and reverse the degradation of all ecosystems, terrestrial, aquatic, and marine and depends heavily on interdisciplinary collaboration and testing of globally used restoration practices.

- The complexity of the interacting systems (and their associated indicators) in the ocean environment creates substantial challenges in dealing with uncertainty, interpreting unexpected trends and relationships,

and developing future projections. Advances in coupled ecologic-economic modelling, particularly in fisheries and climate research, will provide guidance in evaluating best practices for modelling data and for dealing with the cumulative effects of uncertainties generated within individual modelled systems. It is hoped that the scientific community will contribute to the development and application of these Ocean Accounts by advising on appropriate classifications and condition indicators, by helping to understand the role of ecosystem processes in providing services and by interpreting the results of the accounts.
- An additional challenge is to collect the required data with limited financial resources. Global efforts are underway (see **Data sources and platforms for Ocean Accounts**) to maximize the effectiveness of ocean observing systems for collection of relevant and consistent data sets. Improved technologies that enhance the capabilities of tracking vessels and migratory species may also prove beneficial. ESCAP is addressing the needs for global data selection and integration using the framework by producing an inventory of global data and proposing a global map of ocean ecosystems, consistent with this framework.
- For many ecosystem types, particularly in the marine environment, there is a lack of consensus in the scientific community on specific environmental indicators which accurately identify ecosystem health and function through time. While efforts to develop indicators of ecosystem health are a focus of research across all marine ecosystem types, progress varies between ecosystems types. Furthermore, the informative power of available metrics will have to be balanced with the feasibility of use, which includes intellectual barriers and the cost of collecting the data at a satisfactory frequency.
- The need for improved reporting systems and visualization tools for the dissemination of ocean accounts data to the public and policy makers. These will increase the ability of crosstalk between independent governmental agencies which are stakeholders in the overall account building process. These are discussed as “dashboarding” in **Scope boundaries of Ocean Accounts.**

1.4 Statistical foundation of Ocean Accounts

1.4.1 An accounting perspective

- We all encounter the basic principles of accounting in our daily lives. Our bank accounts record the opening balance at the beginning of the month, withdrawals and deposits over the month and the ending balance. The opening balance is our “financial asset”, withdrawals and deposits are reductions and additions to those assets. If withdrawals and deposits are in foreign currencies, these are first converted to a common currency. If the opening balance, minus withdrawals, plus deposits does not add up to the closing balance, then some item has been mis-recorded or mis-calculated. Our financial books should balance, as should our accounts for natural capital.
- Withdrawals for our monthly mortgage payments is an investment in our “produced assets”, which is recorded in a separate account. If our houses are not well-maintained, their value may decrease. The value of our cars depreciates over time. Both may have substantial liabilities in terms of maintenance or repair costs. Our “net worth” is the sum of all our assets and liabilities. Regularly reviewing our accounts tells us if our net worth is increasing or decreasing.

1.4.2 Accounting for the economy and the environment

- Environmental economic accounting balances nature’s books. The term “accounting” is broader than simply financial accounting; stocks and flows of environmental assets are also accounted for in physical terms. An “account” is a summary table of either environmental assets (opening stock, additions, reductions, closing stock) or their flows into, within or out of the economy (supply, use of natural inputs and residuals, the left-overs: pollutants and wastes).
- To manage our impacts on environmental assets so that they provide benefits into the future, we need to measure the locations and quantities of those assets, their additions and reductions, their conditions, their benefits to people and what people are doing to improve or degrade them. Accounting principles highlight

the need to account for all assets and all flows. They also require us to convert to standard units, apply standard concepts, such as pricing, and work within specified accounting periods.
- The environment is an asset that contributes directly to economic production, but more so to other important aspects of life on earth. Fish are important economically, but also socially in terms of nutrition and culture, and environmentally as part of the complex ecosystem. The amount of fish harvested may be more than the capacity of the stock to reproduce, thereby depleting the asset. Pollution and other human activities may also degrade the fish's habitats, further reducing their capacity to provide economic and social benefits. Similarly, the pollution may decrease the ocean's economic value but will also harm the quality of life of life of affected people and the capacity for ecosystems to function.

1.4.3 Building on existing frameworks and standards

- Data on environmental assets and their benefits to people come from many sources and are collected using different definitions and classifications. Measurement frameworks help to standardize these data across sectors, disciplines, and countries. Fortunately, we have existing statistical frameworks that we can build on to help standardize data for the ocean.
- The SNA records revenues from extracting, harvesting, and capturing natural resources (mining, agriculture, forestry, fisheries, water supply, energy supply) in monetary terms. These natural inputs to the economy are, in turn, sold to and used by other economic sectors. To do this, the SNA is based on clear classifications of institutional sectors (industries) and institutional units (businesses, governments, households) and clear definitions and measures of revenues, costs, prices, imports, and exports. GDP, the measure of economic production by resident institutions, is one headline indicator that the SNA produces. Another is balance of trade, the difference between a country's imports and its exports. The SNA can also be used to track assets, but normally focuses on assets with economic value: fixed capital (buildings, equipment, and infrastructure) and financial capital as part of the National Balance Sheet.
- The SEEA-CF records environmental assets and the flows of natural inputs, products, and residuals in physical and monetary terms, applying the same concepts, definitions and classifications as the SNA.
- SEEA-EEA builds on the principles of the SNA and SEEA-CF to better measure ecosystems as integrated assets, their condition, and the services they provide to people. Viewing ecosystems as "integrated assets" recognizes that the ocean is more than a source of fish; it is also important for coastal protection, carbon sequestration, climate regulation and recreation, among others.

1.4.4 Integrated physical and monetary accounting

- Recording the stocks of environmental assets in physical terms can support the measurement of the economic value of those stocks. The SEEA, unlike the SNA, "includes all natural resources and areas of land of an economic territory that may provide resources and space for use in economic activity" (SEEA-CF para 1.48). SEEA-CF asset accounts record the opening balance, additions, and reductions, and closing balance. These principles can be applied to mineral and energy resources, land, soil, timber resources, aquatic resources, other biological resources (crops and livestock) and water.[7]
- Flows of these environmental assets to the economy are recorded as supply and use tables. **Supply tables** in physical terms, recording the quantities extracted, harvested, or captured and which institutional unit (including imports) supplies that natural input. This can be linked back to the asset accounts as reductions or additions. **Use tables**, in physical terms, record the flows of products within the economy and which economic unit (including exports) uses that natural input.
- Supply and use tables in monetary terms can be compared with the values of transactions recorded in the SNA. Asset accounts can tell us whether and why the asset is increasing or declining. They can also tell us something about how long that asset is expected to last, given the anticipated supply (from the supply tables). Comparing physical and monetary tables can reveal inconsistencies in the accounts. For example, the SNA may undercount the contributions of small-scale fishers or household production because of under-reporting. From the asset accounts, we may see a reduction in stock that is not reflected in the monetary supply tables. This may be a sign of unreported or illegal activity

- The SNA and SEEA-CF accounts are generally produced for administrative areas; that is, for a country or state, without further spatial detail. There is also no recording of the condition (quality) of the asset or product. For example, water supply and use accounts generally record the total quantity of water supplied to the country in cubic metres, without regard for the quality of the water supplied.
- However, the location and condition of an ecosystem affects its capacity to provide services, the potential for people to benefit from it and the impact of people on it. Therefore, ecosystem accounts are based on spatially detailed data, including data on the condition of those ecosystems and the location from which services are provided.

> ⓘ [7] Monetary asset accounts for water are not defined in the SEEA-CF. Since water is often considered a public good and sold at below the cost of production, the NPV approach would generate a negative rent.

1.4.5 Ecosystem accounting

- To compile, integrate and analyse spatial data from several domains, SEEA-EEA introduces a spatial framework based on a hierarchy of spatial statistical units and an ecosystem classification (see **Spatial data infrastructure for Ocean Accounts**). Together, these form the basis of the Ecosystem Extent Account, which maps ecosystems of different types (forest, grassland, mangrove, etc.). Ecosystem Condition Accounts and Services Supply Accounts apply the same spatial framework facilitating the overlaying of data from these accounts.
- Ecosystem Condition Accounts compile quality measures with respect to a reference condition. Identified variables, which are suited to represent the condition of a specific ecosystem type are converted into indicators by comparison with a standard, such as the species diversity of the same area in the past.
- Ecosystem services are “contributions that ecosystems make to benefits used in economic and other human activity” (United Nations, 2017. p68). There is no international standard classification of ecosystem services. However, the SEEA Ecosystems revision process is developing a list of common, widely available ecosystem services. See **Classification of ocean ecosystem services**.
- Ecosystem Services Supply Accounts record the provision of ecosystem services by different ecosystem types. These may be aggregated from small spatial units or disaggregated from national statistics. For example, the provision of “fish” by “estuaries” versus “pelagic areas” could be summed up from plot-level data or national fishery production statistics could be attributed to all ocean areas designated for fishing.
- Ecosystem Services Use Accounts record the use of ecosystem services by beneficiary economic units: households, businesses, and governments. Experience in disaggregating beneficiaries spatially and by sub-populations (such as high/low income) using the SEEA-EEA is limited. It is intended that the implementation of Ocean Accounts in national pilots will help develop common approaches to accomplishing this.
- The SEEA-EEA emphasizes that ecosystems can have values beyond their contribution to short-term economic production. These are reflected in the classification of ecosystem services, which contains services such as “flood control” and “characteristics of living systems that enable aesthetic experiences”. Since there is limited potential to market such services, they are generally measured only in physical terms. The SEEA-EEA suggests monetary valuation be done in a way that is consistent with the SNA. That is, exchange values are “those values that reflect the price at which ecosystem services and ecosystem assets would be exchanged between buyer and seller if a market existed” (United Nations, 2017. p97). However, recent discussions on the SEEA Ecosystems revision suggest that future versions will include guidance on appropriate methods for measuring and applying non-market or welfare values.

1.4.6 Extensions for ocean accounting

- The Ocean Accounts Framework adapts and extends the concepts of the SNA, SEA-CF, and SEEA-EEA to apply better to the ocean. It includes additional guidance on:
    - Measuring or qualitatively describing components of the **ocean economy** and **governance** that are not addressed in the SNA or SEEA;

- **ocean spatial units** and **ocean ecosystems types**, while maintaining consistency with SEEA-CF Land Accounts, and SEEA-EEA Ecosystem Extent for terrestrial and freshwater ecosystems;
- **spatially detailed physical supply and use of ocean-related natural inputs** from the SEEA-CF (such as energy, metals and minerals, aquatic resources);
- **spatially detailed information on sources of residuals** from the SEEA-CF, especially land-based water emissions and solid wastes,
- spatially disaggregated information on expenditures on environmental protection from the SEEA-CF, and
- further disaggregation of beneficiaries of ecosystem services from the SEEA-EEA, by type and location. It is important to recognize such disaggregation must carry a metadata flag to ensure the resultant disaggregated data are used in the correct manner.

1.5 Practical relevance and utility of Ocean Accounts

- Ocean Accounts are designed to be relevant to and practically useful for the development of ocean sciences, [8] national statistical systems, and evidence-based governance of oceans. The rationale for their use in these three contexts can be summarised as follows.

> [8] Defined broadly, including all relevant physical, biological and social sciences, and interdisciplinary activities connecting these disciplinary domains.

1.5.1 The scientific rationale for Ocean Accounts

- Modern ocean science is characterised by increasing reliance on complex and large-scale data inputs, and by a proliferation of distinct expert communities operating within and between the broad domains of physical, biological, and social research. In this context, the Ocean Accounts Framework can provide a useful means to:
  - *Integrate data and statistics across disciplines*—it provides a conceptual structure for the integration and/or coherent presentation of data and statistics concerning marine and coastal environments, social circumstances, and economic activity. Creation of such structure could also serve to drive improved standards and consistency for the collection and communication of primary data.
  - *Provide a more holistic understanding of complex systems*—The integrated and coherent nature of information within the framework provides a foundation for holistic analysis of complex and interlinked social, environmental, and economic phenomena and trends.
  - *Communicate science to decision-makers*—As noted previously, Ocean Accounts are specifically intended to inform and enable public policy decision-making about oceans, and related analysis and research. They present multiple outputs of ocean-related scientific research within an overarching structure that is compatible with existing national accounting processes and standards. This supports *(1)* communication with a wider range of decision-makers (for example macro-economic decision-makers who do not typically engage directly with environmental science), and *(2)* the public legitimacy of scientific information by subjecting it to the rigour of national statistical processes and accounting principles.

1.5.2 The statistical rationale for Ocean Accounts

- Environmental-economic accounting has been conducted in over 90 countries over the past 35 years. At least 60 countries regularly produce one or more SEEA account. These have focused on accounts seen as more technically feasible or immediately policy relevant: water, land, energy, and waste. Ecosystem accounting is relatively recent, so fewer countries have attempted them. The estimated 29 countries that have produced ecosystem accounts have generally focused on terrestrial and freshwater areas. The open ocean as a land cover type was not included in the SEEA-CF and had only been added to SEEA-EEA in the Technical Recommendations issued in 2017. However, the SEEA-EEA's research agenda did include developing guidance for marine ecosystems.

- The focus on terrestrial and freshwater ecosystems may have also been for technical feasibility and policy priority reasons. There had been little experience in broadly measuring the ocean, and its importance to life on earth is still not well understood. However, with the advent of SDG14, the need to measure the condition of the ocean and its importance to people became a priority for official statisticians. Some countries had already been extending the concepts of the SEEA-CF and SEEA-EEA to the ocean. In the absence of statistical guidance, they applied different approaches and made different assumptions.[9] While these constituted valuable experimental experiences, none were sufficiently broad to encompass all the concerns expressed in SDG14 and other ocean-related public policy objectives.

[9] For example, Statistics Canada's Measuring Ecosystem Goods and Services (https://www150.statcan.gc.ca/n1/pub/16-201-x/16-201-x2013000-eng.htm), which included biomass extraction from the ocean, dependence of coastal communities on fishing. See also Australia Bureau of Statistics accounts for the Great Barrier Reef (https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4680.0Main+Features12017?OpenDocument).

- Ocean accounts are a multidisciplinary framework. The success of its implementation and eventual use rests on involvement and collaboration of stakeholders with diverse yet complementary knowledge and expertise from statistical, scientific and policy domains. At the national level, collaboration across different government agencies including but not limited to statistics, environment, marine and coastal resources, science, and finance and planning is vital. Ensuring this collaboration requires statistical approaches to ensure standardized formatting and processing of the these interdisciplinary data.
- Ocean Accounts are specifically intended to inform and enable public policy decision-making about oceans, and related analysis and research. They present multiple outputs of ocean-related scientific research within an overarching structure that is compatible with existing national accounting processes and standards. Using statistical approaches to combine this information supports *(1)* communication with a wider range of decision-makers (for example macro-economic decision-makers who do not typically engage directly with environmental science), and *(2)* the public legitimacy of scientific information by subjecting it to the rigour of national statistical processes and accounting principles.

1.5.3 The governance rationale for Ocean Accounts

- At local, national, and international scales, oceans governance processes are increasingly expected to deliver a wide and balanced range of social, economic and environmental objectives. At the international level, all countries have committed since 2015 to achieving the 17 Goals and 169 Targets recognised in the 2030 Agenda for Sustainable Development. These Sustainable Development Goals (SDGs) and Targets relate to diverse challenges in particular: poverty; hunger; health and well-being; quality education; gender equality; clean water and sanitation; affordable and clean energy; decent work and economic growth; industry, innovation and infrastructure; inequality; sustainable cities and communities; responsible consumption and production; climate action; life below water; life of land; peace, justice and strong communities; and partnerships for sustainable development. SDG 14 establishes a commitment to "Conserve and sustainably use the oceans, seas and marine resources for sustainable development", accompanied by 10 Targets.[10]
- At national and local levels, a growing number of countries have established policies and programmes designed to accelerate social and economic development and protection of their coastal and marine environments. Most coastal and island nations designate marine protected areas (MPAs) and many actively engage in marine spatial planning (MSP). Some of these characterise the environment as a critical economic asset, consistent with the explicit recognition in the Preamble of the 2030 Agenda that "social and economic development depends on the sustainable management of our planet's natural resources."

- These governance objectives create demands for holistic and integrated analyses of ocean-based development, informed by holistic and integrated evidence including the evidence presented in Ocean Accounts. These demands are reinforced by a range of international political commitments to develop environmental valuation and accounting, including for oceans. For example, **SDG 15.9** calls on all countries, by 2020, to "integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts." **SDG 17.19** calls on all countries, by 2030, to "build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product and support statistical capacity-building in developing countries."
- An initial linkage between the Ocean Accounts Framework and SDG14 and other ocean-related targets and indicators presented in **Appendix 6.5**. The creation of Ocean Accounts is fundamental to these policy commitments because the accounts provide the essential information to establish baselines and monitor progress towards or away from policy goals relevant to the commitments made. Without creating and sustaining Ocean Accounts and the data and statistical systems needed to support them, it is difficult to know whether any of the policies are achieving their desired ends.

[10] Concerning: marine pollution; marine and coastal ecosystems; ocean acidification; illegal, unreported and unregulated (IUU) fishing; conservation of marine areas; fisheries subsidies; economic benefits for Small Island developing States; scientific and technical capacity building and transfer; small scale and artisanal fishing; and implementation of international law concerning oceans.

2. Structure of Ocean Accounts

Table of Contents

- This section provides the conceptual basis for Ocean Accounts. As noted in the **Introduction**, existing statistical standards, the SNA and the SEEA provide much of the foundation of Ocean Accounts. However, accounting for the ocean requires an adaptation and extension of these standards in many areas. Elaborating on **Figure 1**, **Figure 3** below illustrates the detailed structure of the Ocean Accounts Framework: The components of the framework can be summarised as follows:
- **Table groups and subcomponents:** as explained previously, an Ocean Account is comprised of one or more tables that can be organised into different subject matter groups, namely:
    - environmental assets (extent and condition of biotic and abiotic components);
    - flows of goods and services (ocean services) from the ocean to the economy;

    - flows from the economy (pollutants, residuals) to the ocean environment;
    - "Ocean Economy Satellite Accounts" comprising economic contributions of ocean-related industry sectors;
    - features of ocean governance that shape our impact on the ocean environment and economy;
    - combined presentations including benefits and costs associated with the ocean environment and economy; and
    - national ocean wealth comprised of social, environmental and economic assets;
- Each table records quantitative information (monetary value, or physical status) or qualitative descriptors (e.g. names of applicable laws & regulations) or a combination these.
- **Relationships between the phenomena that are accounted for in each of the Table groups:** including flows between ocean environmental assets and the economy measured in physical or monetary terms, relevant flows of goods and services within the economy measured in monetary terms, and governance "flows" (e.g. management decisions, investments, establishment of laws and regulations) that affect specific components of the ocean environment and economy (and consequently the associated societal benefits and costs).
- **Common (linked) statistics:** In several cases, the same information is duplicated across multiple Tables. For example, the monetary value of ocean protection and management expenditure is recorded in the Governance tables, and also in those concerning the ocean economy. This duplication is designed to ensure that conceptually relevant information is integrated into each Table group for ease of reporting.
- The remainder of this Section is devoted to explaining each component of the Ocean Accounts Framework in detail.

2.1 The spatial data infrastructure for Ocean Accounts

- The ocean is large, three-dimensional, moving, much is outside national jurisdictions and spatial data are collected by many local, national and international organizations. This poses challenges to mapping; therefore, only 20 percent of the ocean seafloor has been mapped in terms of depth (bathymetry) and less than 0.001 percent has been sampled in terms of substrate and biota (DOALOS, 2016, Chapter 33). Only the surface of the ocean is visible from satellite. This requires special attention to establishing a spatial data infrastructure that will serve to integrate many types of data including from local *in situ* studies.
- The Ocean Accounts Framework accommodates both spatially explicit and spatially independent information. For example, statistics documenting protection and management expenditures might be compiled at a national level without spatial detail. Accounts on ecosystem extent, condition and services supply might be built up from site-level data.
- Spatially explicit data are more easily compiled into Ocean Accounts when they are standardized according to an agreed National Spatial Data Infrastructure (NSDI). An NSDI may include or be independent of a national Marine Spatial Data Infrastructure (MSDI). A comprehensive NSDI would set the spatial standards for the common treatment of data on terrestrial, freshwater, coastal and marine areas. The coastal and marine components of such an NSDI would include information on bathymetry and extend to the country's EEZ. The entire NSDI/MSDI would include a common definition of "coastal", an agreed shoreline, a shared classification of ecosystem types, agreed projections and scales, as well as common protocols for assessing, integrating and updating data. This then becomes the standard for compiling spatial ocean data within a Geographic Information System (GIS).

Figure 3. Detailed table structure of Ocean Accounts Framework

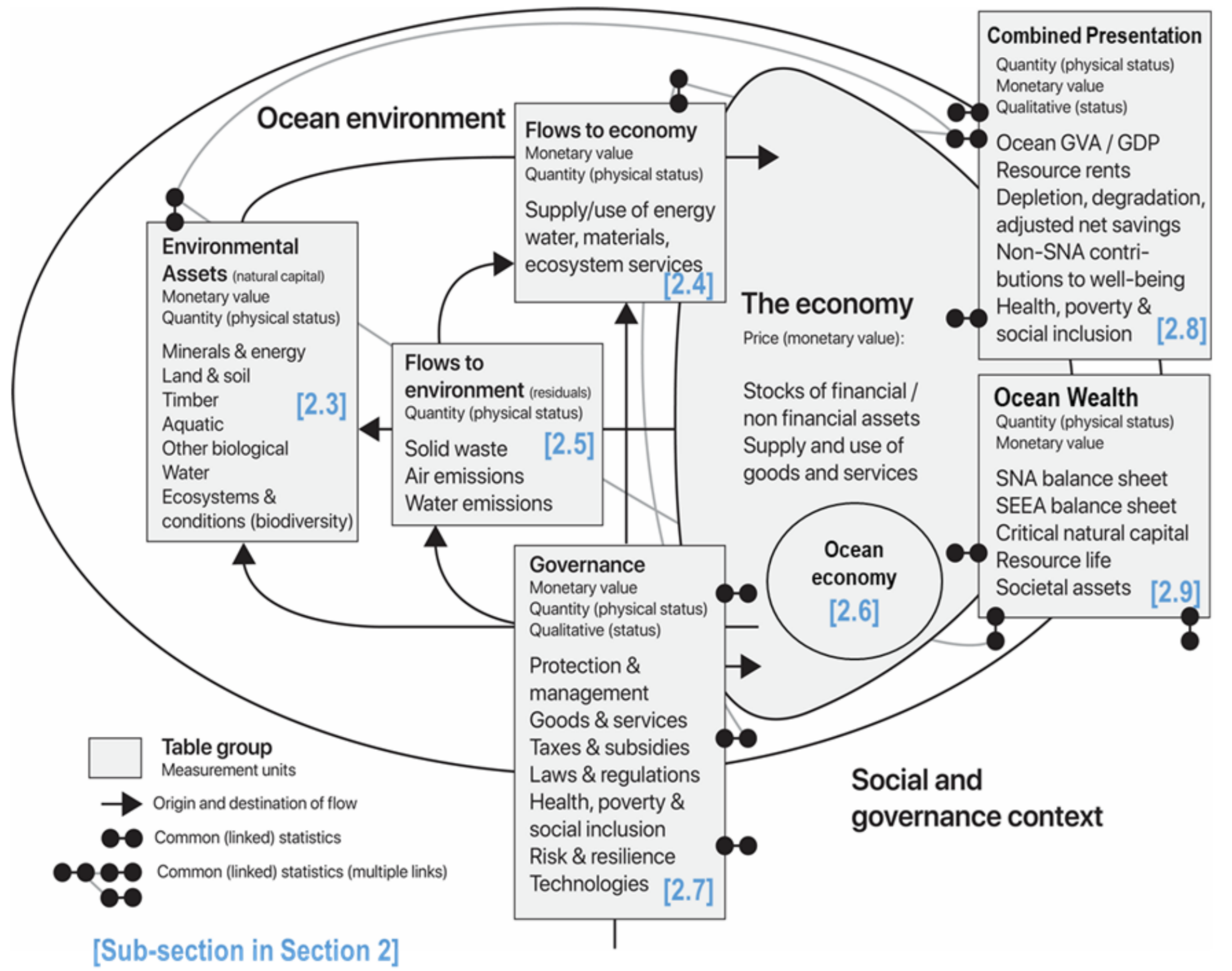


Figure 3. Detailed table structure of Ocean Accounts Framework.

- Having a common spatial standard for terrestrial and marine data would also facilitate the compilation of terrestrial-based sources of pollution (see **Flows to the Environment**). To do this, Ocean Accounts would need compatible data on ecosystems, populations and economic activities summarized by terrestrial drainage basin. Many statistical offices, such as Statistics Canada, regularly produce such socio-economic and environmental data aggregated by drainage basin.
- The Ocean Accounts operate on the same spatial principles as the SEEA-EEA. Basic Spatial Units (BSUs) are the smallest measurement unit. These are classified by an ecosystem classification, such as the IUCN Global Ecosystem Typology (GET, see **Classification of ocean ecosystems**) according to their Ecosystem Type (ET). Ecosystem Assets (EA) are contiguous BSUs of the same ET. The Ecosystem Accounting Area (EAA), such as a country, state, or drainage (catchment) area, is the level at which the ETs are aggregated for reporting purposes. The SEEA Ecosystems revision discussions suggest the Basic Spatial Unit (BSU) as an "operational" concept. That is, the BSU may be required when detailed spatial data are compiled from various sources and then it serves as a common reference. However, data from BSUs can be used to create homogenous EAs, which serve as the level at which most data are maintained.
- The Basic Spatial Unit (BSU) may be as small as a remote sensing image pixel (30-100m), a national grid reference system (1nm) or small administrative unit (e.g., marine statistical area). Smaller BSUs have the advantage of being more homogenous. That is, when delineating ecosystem extent, some ecosystems, such as mangroves, may be in strips of 5m wide and therefore undetectable by satellite at 100m resolution. Since

ecosystems tend to be more complex in coastal areas and data tends to be more generally available, some countries maintain data at finer resolution near the coast. In this case, it may be practical to distinguish between coastal units (CBSU) and marine units (MBSU).

- To the extent possible, all information documented in Ocean Accounts should be progressively attributed to BSUs or EAs, to:
    - build a spatial characterisation of relationships between social, economic and environmental features of oceans,
    - delineate specific ecosystem assets and
    - facilitate assessment of their condition and services provided over time.
- Creating and applying three-dimensional Marine Basic Spatial Units (MBSUs) in an accounting framework are being explored but are not in common use (see for example, Sayre et al., 2017).
- Within an overarching environmental-economic accounting framework, the spatial infrastructure should be mutually exclusive and collectively exhaustive with its terrestrial and freshwater counterparts—for example, MBSUs with Terrestrial Basic Spatial Units (TBSUs). Consistent with the definition of Ocean Assets (see **Environmental asset accounts**), certain BSUs can be classified as both terrestrial and marine, as transitional functional ecosystem types in the IUCN GET. Within this integrated spatial structure (**Figure 4**):

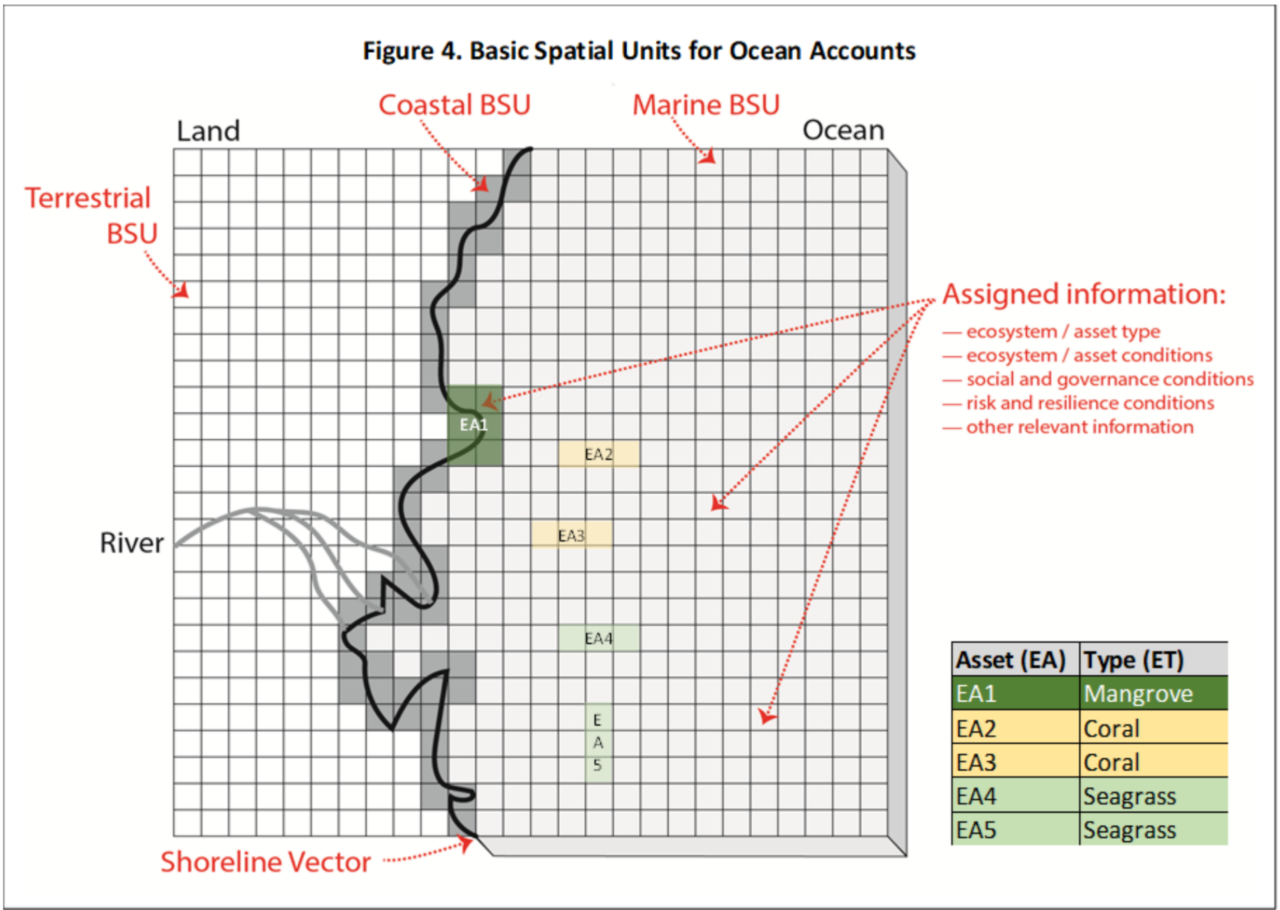


Figure 4. Basic spatial units for Ocean Accounts

- MBSUs designate a three-dimensional volume of ocean including the seabed and subsoil. Alternatively, depending on technical capacity, it could also be considered as several integrated vertical layers: surface, water column, seafloor and sub-seafloor.
    - CBSUs designate a three-dimensional volume of shallow coastal waters (including seabed and subsoil) and a two-dimensional area of land, delineated by a **Shoreline Vector**.

    - TBSUs designate two-dimensional areas or three-dimensional volumes of land. (Note: Terrestrial land and ecosystem accounting frameworks are, at present, predominantly based on a two-dimensional spatial framework. Use of an integrated three-dimensional framework for both terrestrial and ocean accounting is being considered as part of the SEEA revision process. For example, a three-dimensional spatial infrastructure for terrestrial ecosystems would help distinguishing tree canopy from underlying grasses and wetlands. The spatial framework presented in this guidance anticipates this change but is intended to be practically interoperable with current two-dimensional terrestrial accounting.) Being the foundation of terrestrial environmental-economic accounting, TBSUs are beyond the scope of the Ocean Accounts Framework.
    - The summary tables suggested for Ocean Accounts generally show summary data on extent, condition, services supply or value by ET.
    - Ideally information is compiled with enough spatial detail to establish relationships between the components of the framework (assets, input flows, output flows, economy and governance). Tables outlined below are aggregated spatially for reporting purposes by "accounting area", which could be all national coastal and marine areas, smaller administrative areas such as provinces or marine management areas, or environmental areas such as MPAs. The Malaysia ESCAP Ocean Accounts pilot has compiled accounts maintaining separation between inshore (continental shelf) from offshore (deep sea) areas.
- Neighbouring countries could compile comparable Ocean Accounts to study the transboundary impacts and impacts relating to flows to and from Areas Beyond National Jurisdiction (ABNJ). It would then be useful to have a common spatial data infrastructure among these countries.

2.2 Scope boundaries of Ocean Accounts

- The scope of the Ocean Accounts Framework can be defined in terms of two key scope boundaries, in addition to those defined in the SEEA-EEA (ecosystem services and assets beyond the SNA production boundary). Ocean Accounts also require the definition of: *(1)* spatial boundaries of the ocean environment; and *(2)* the sectoral boundary of economic activity determining the "Ocean Economy". Concerning spatial boundaries, the Ocean Accounts Framework is currently designed to cover coastal and marine environments within the seaward limit of a country's national maritime zones—i.e. up to the seaward limit of the EEZ and/or continental shelf. Global-level Ocean Accounts are also feasible and could, for example, demonstrate the extent and condition of the world's costal and marine environments, locations of high service provision and areas that are most degraded and stressed including those in areas beyond national jurisdiction (ABNJ).
- Biophysical definitions of "coastal" often define an area up to 100km inland (or 50m in elevation, whichever comes first) and to 50m in depth seaward (MA 2005). However, the US often includes the Great Lakes as "coastal". Notwithstanding local definitions, this is the general definition applied in the Ocean Accounts. This then requires care in adhering to national definitions as well as coordinating with others working on terrestrial and freshwater areas. For example, estuaries can range from freshwater, to brackish to saltwater. Therefore, parts of the estuary may be under the mandate of different agencies and data may be collected using different boundaries. Further, such ecosystems may cross administrative boundaries, including national and state borders. This highlights the importance of agreed national and maritime boundaries. The Ocean Accounts framework is intended to be consistent and interoperable with ongoing terrestrial and freshwater environmental-economic accounting efforts.
- Concerning the scope of the "Ocean Economy", there is no widely agreed definition (OECD 2016. Ocean economies are identified by many terms including "ocean economy", "ocean industry", "ocean sector", "marine economy", "marine industry", "marine activity", or "maritime economy" or "maritime sector". The term "blue economy" is increasingly being used in the context of sustainable and inclusive use of the ocean and as a parallel to "green economy". As explained in **Flows to the economy**, different institutions and initiatives approach this definitional question differently. Conceptual definitions of the ocean economy include some or all the following:
    - Economic activity that is physically located on the ocean (e.g. shipping, fisheries, offshore oil and gas);

    - Economic activity that is physically proximate to the ocean (e.g. coastal tourism, coastal aquaculture);
    - Economic sectors, located on land, that depend on natural inputs from the ocean environment, either biotic or abiotic (e.g. fish processing, construction materials);
    - Economic activity that provides goods or services to sectors located on the ocean (e.g., shipbuilding, marine engineering);
    - The market value of natural inputs (fish, minerals) potentially derivable from the SEEA-CF monetary flows accounts and market and non-market value of ecosystem services potentially derivable from the SEEA-EEA services supply accounts.
    - "Indirect" or "intermediate" expenditures on goods and services used by the above "direct" economic activity; and
    - "Induced" or "final demand", which include expenditures enabled by the above "direct" and "indirect" expenditures.
- A comprehensive list of characteristic ocean-related economic activities is presented in **Flows to the economy**. This is the basis for producing "Ocean Economy Satellite Accounts". Ocean Economy Satellite Accounts calculate the annual production of ocean-related sectors as their contribution to national GDP based on data extracted from the SNA and other economic statistics. However, a national economy also includes its assets and liabilities (National Balance Sheet), gross fixed capital formation (investments), depreciation of assets, imports/exports (Balance of Trade) and non-market goods and services. Some of these macro-economic concepts of the ocean economy are explored in this Guidance, but for the most part is considered future research (See **Research agenda for ocean accounting**).
- The remainder of this section establishes the **Asset Accounts** upon which the Ocean Accounts are based. It then reviews the **Flows to (supply) and within (use) the Economy** of ocean services from those assets and **Flows from the National Economy** (residuals, pollutants) that affect the quantity and condition of ocean assets. **Ocean Economy Satellite Accounts** are also flows, but measured in terms of the contribution of characteristic ocean sectors to the national economy. The experimental **Governance Accounts** present information on collective decision making about the ocean in combination with the context in which decisions are made. **Combined Presentations** are the summary "report card" that brings together the key indicators from other accounts that can serve as a dashboard for decision making. **Ocean Wealth** emphasizes the many measures of ocean assets and their values to the economy and society.

2.3 Environmental asset accounts

2.3.1 Defining environmental assets

- Assets are things of value to society—the natural, human, financial, social, intellectual, and produced wealth from which we derive benefits. The ocean is such an asset, but it is often not appropriately valued in decisions and plans. A cornerstone of the Ocean Accounts Framework is to provide a means to comprehensively measure the embodied wealth of the ocean, represented not only in terms of short-term financial gain, but also in terms of longer-term sustainability.
- In economics, assets are defined as stores of value that, in many situations, also provide inputs to production processes. More recently, there has been consideration of the value inherent in the components of the environment and the inputs the environment provides to society in general and particularly, the economy. The terms "environmental asset" and "natural capital" are commonly used to denote the source of these inputs, which may be measured in both physical and monetary terms. The Ocean Accounts Framework covers a subset of environmental assets that are located wholly or partly seaward of the mean high-water line, including coastal and marine areas. Note: that the 1982 Law of the Sea Convention establishes a territorial sea baseline as the spatial boundary between territory and maritime zones. These baselines are either the low-water line along the coast or straight lines designated in accordance with Part II Section 2 of the Convention. The spatial scope of ocean assets (and consequently ocean accounts) is based on biophysical factors and is decoupled from legal boundaries between territory and maritime space.

- It would be beneficial for the application of the framework to include produced capital (infrastructure, such as ports, bridges, and harbours) and human capital in the definition of ocean assets. In some respects, produced capital provides a service, it is at risk of extreme events and its construction and operation impacts the environment. Similarly, human, and intellectual capital is enhanced by learning about and experiencing the ocean, which is considered a cultural ecosystem service. Given the complexity of working through the accounting implications, this will be a topic of future research (See **Research agenda for ocean accounting**).

2.3.2 General classification of ocean assets

- The SEEA–CF and SEEA–EEA establish a general classification of environmental assets that can be directly applied for ocean accounting purposes, as follows:
    - Individual environmental assets as defined by the SEEA-CF:
    - **Minerals and energy resources:** including deposits of oil, natural gas, coal and peat, non-metallic minerals, and metallic minerals, including scarce or valuable dissolved minerals,
    - **Land and seabed:** delineating the space in which economic activities and environmental processes take place and within which environmental assets and economic assets are located. For ocean accounting purposes, land also includes areas covered by water at high tide, the seabed within a country's exclusive economic zone, and a country's continental shelf defined in accordance with the 1982 Law of the Sea Convention.
    - **Soil and seabed substrata:** including semi-terrestrial soils of the intertidal area, and seabed substrata types such as rock, coarse sediment, mixed sediment, sand and muddy sand, and mud and sandy mud.
    - **Timber resources:** defined by the volume of trees, living or dead, including all trees regardless of diameter, tops of stems, large branches and dead trees lying on the ground that can still be used for timber or fuel. Mangrove forests are the principal living source of timber resources within the spatial scope of Ocean Accounts.
    - **Aquatic resources:** including cultivated or naturally occurring fish, crustaceans, molluscs, shellfish, and other aquatic organisms such as sponges and seaweed, as well as aquatic mammals such as whales. The aquatic resources for a given country comprise those resources that live within maritime zone limits throughout their life cycles. Migrating and straddling fish stocks are considered to belong to a country during the period when those stocks inhabit its EEZ. Note: See also SEEA–CF Section 5.9.2 concerning accounting for highly migratory and straddling fish stocks, and fish stocks that complete their life cycle on the high seas.
    - **Other biological resources:** including cultivated or naturally occurring animals and plants other than timber and aquatic resources. This could include coastal crops, livestock and wild foods contributing to a broader definition of ocean economy.
    - **Water resources:** including fresh and brackish water in inland water bodies, including groundwater and soil water, focusing on abstraction from the ocean and outflows to the ocean. Seawater has not been treated as an asset in the past, although its supply and use are included in water accounts.
    - **Ecosystem assets** as defined by the SEEA-EEA**:**
    - **Ecosystems**: namely dynamic complexes of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit (As defined in Article 2 of the Convention on Biological Diversity). Ecosystem assets are an important focus of ocean accounting because they yield flows of valuable, and in many cases irreplaceable, benefits to people. Ecosystems are classified by type (e.g., forest, mangrove, seagrass) and characterized by their extent, condition, and use.
- There are overlaps between individual environmental assets and ecosystem assets. For example, a coral reef ecosystem includes the aquatic resources (fish, crustaceans, and plants) that live in it. This is not so much an issue for the physical measures of extent, condition, and use; coral reefs are represented in hectares of area they cover, fish are represented by the tonnes of stock of a species. However, when these come to be valued in monetary terms, the value of a hectare of coral reef likely includes the value of the fish living in it. Keeping both individual environmental assets and ecosystem assets in the same tables will encourage examining the

comprehensiveness of ecosystem services valuations. For example, determining whether all assets have been considered. It will also encourage avoidance of double counting if assets valued are made explicit.

2.3.3 Classification of ocean ecosystems

- Ecosystem types (ETs) should be classified so they can be consistently organised within the ocean accounting framework over time. There is currently no international standard classification of ocean ecosystems. Many global and regional classifications exist (**Appendix 6.7**). Some are based on habitat types, benthic properties or a combination of characteristics such as depth, temperature, geology, chemical composition, biota, etc.
- Coastal and marine ecosystems often considered in assessments include (but are not limited to):
  - Coastal: beaches, (sand dominated), seagrass beds, mangrove forests, intertidal and subtidal rocky shores, oyster reefs, kelp forests, and tropical coral reefs,
  - Marine (to shelf): benthic soft-bottom habitats (sponges and sessile filter feeders), phytoplankton communities (upper water column), zooplankton communities (upper and mid water column)
  - Marine (shelf to EEZ): Aphotic benthic sessile communities, uninhabited soft bottom (e.g., sand,), uninhabited rock, pelagic phytoplankton (upper water column), zooplankton communities (upper and mid water column), migratory pelagic species (pelagic fish and cetaceans).
- The lack of detailed data on the open ocean results from the lack of historical research on open ocean benthic ecosystems. Due to the lack of data on biota existing there (less than 0.001 percent has been sampled quantitatively, (DOALOS, 2016, Chapter 33)), such deep-sea environments are often characterized by their landform (e.g., seamounts, hydrothermal vents) and substrate (sandy, rocky). Two biotic communities often identified include cold-water/deep-water corals and sponges.
- The SEEA Ecosystems revision process has agreed to consider the IUCN Global Ecosystem Typology (GET, described below) as a “reference classification”. That is, in the absence of an agreed national classification of ecosystems, the GET is considered a useful starting point as well as a reference for international comparison.
- The IUCN GET was developed by the IUCN Red List of Ecosystems Thematic Group. It combines process-based and biogeographic approaches across the whole planet, with the aim of developing a scalable framework that supports generalisations about groups of functionally-similar ecosystems and recognises different expressions within these groups defined by contrasting biotic composition (Note: Details omitted pending publication) The broad structure of this global ecosystem typology is listed in **Figure 5** below. A list of realms, biomes and ecosystem functional groups relevant to ocean accounting is provided in **Appendix 6.2**.
- Since Ocean Accounts require the establishment of ETs, classification at the functional group (Level 3) may be most useful. At this level, the IUCN GET identifies 22 marine functional groups (such as seagrass meadows) and 12 transitional functional groups (such as intertidal forests and shrublands (mangroves)). Although ecosystem assets can be disaggregated to the species level, this is rarely useful for broad assessments of ecosystem services and benefits, given the current state of data. However, information at the local ecosystem type (Level 6) may be relevant for specific issues or very localised natural resource management.
- ESCAP has developed a feasibility study for mapping global ocean ecosystems, based on the United States’ **Coastal and Marine Ecological Classification System (CMECS).** CMECS (See **Appendix 6.7)** classifies the environment into biogeographic and aquatic settings that are differentiated by features influencing the distribution of organisms, and by salinity, tidal zone, and proximity to the coast. Within these systems are four underlying components: water column, geoform, substrate and biota. CMECS may provide more detailed classes for some marine ecosystems.

Figure 5. Structure of the IUCN Red List of Ecosystems global ecosystem typology

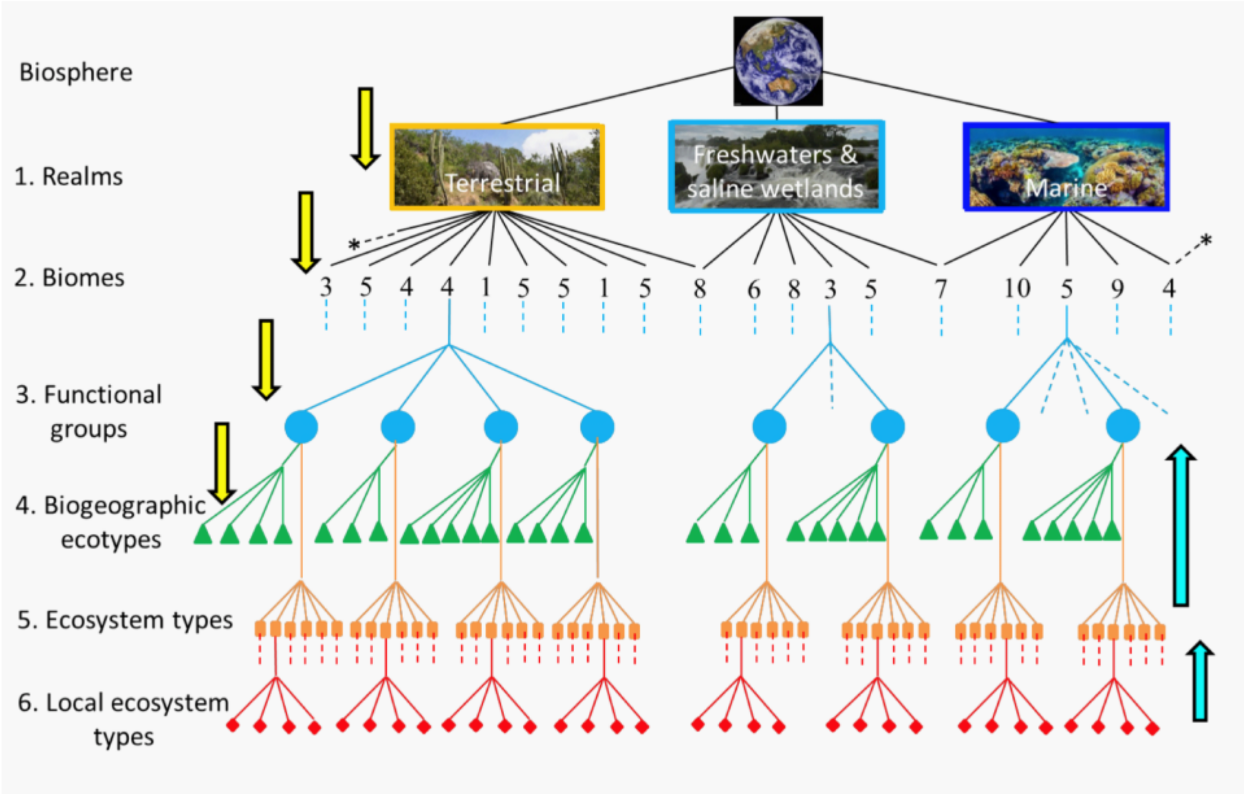


Figure 5. Structure of the IUCN Red List of Ecosystems global ecosystem typology

Source: https://iucnrle.org/about-rle/ongoing-initiatives/global-ecosystem-typology/

- The IUCN-GET is undergoing testing through the SEEA Ecosystem revision process. This entails comparison with existing national classifications. Testing and experimentation with the IUCN-GET and CMECS in future pilot studies is encouraged.

2.3.4 Physical asset accounts

- Table 5.2 in the SEEA-CF provides a general structure for physical accounts for many different environmental assets. It shows the diverse concepts that come in to play for different asset types. Opening and closing stocks can be represented for all asset types: minerals and energy, land, soil, timber, aquatic resources and water. However, not all reasons for additions and reductions are valid or obvious for each asset type. For example, timber, aquatic resources and water are “renewable” in that additions come from natural growth or from precipitation. Mineral resources, however, would not be subject to additions from natural growth.
- For each asset types, it is feasible to distinguish parts that are relevant to the ocean. For example:
    - **Mineral and Energy Stocks** occur under land, freshwater, coastal and marine areas. These are not often distinguished as such in national statistics, but could be if the objective of the Ocean Accounts is to clearly delineate coastal and ocean-related mineral and energy assets;
    - **Land Accounts** (cover and use) could be extended to include offshore coastal and marine waters;
    - **Timber Accounts** could distinguish coastal/brackish water timber resources such as mangroves; and
    - **Aquatic Resources Accounts** could distinguish freshwater from brackish, coastal, and marine species.

- Making these distinctions would use the same data sources as for SEEA-CF accounts but would require more detailed information on the locations of the assets.
- It is important to understand the extent of the assets because the type of asset and its condition influences its capacity to provide services. Ocean assets, including ecosystem assets provide services that are spatially significant and, in some instances, relevant to other assets. For instance, seagrass may be providing local nursery habitat for fish but once the juveniles come of age they move to another ecosystem and live to adulthood (there are also numerous species that live to adulthood in bays and then breed in open oceans, and vice versa). Further, there may be different types of seagrass providing different types of services – not all seagrass provides nursery habitat.

Table 1. Physical Asset Extent Account

	Ecosystem assets			**Individual environmental assets**	
	Mangroves	Seagrass	Coral reef	Minerals	Fish stocks
Opening stock					
+ Additions to stock					
Managed expansion					
Natural expansion					
Reclassifications					
Discoveries					
Reappraisals (+)					
TOTAL additions to stock					
– Reductions in stock					
Managed regression					

Natural regression					
Reclassifications					
Extractions/ harvesting					
Reappraisals (-)					
TOTAL reductions in stock					
= Closing stock					
Measurement Units	*Area*	*Area*	*Area*	*Weight, litres*	*Weight, number*

Note: Darkly shaded areas represent undefined measures for ecosystem assets (extractions/harvesting) and expansion of minerals stocks. Terminology still requires harmonization between SEEA-CF and SEEA-EEA. For example, extraction/harvesting refers to individual assets in the SEEA-CF. Ecosystem assets are treated in the SEEA-EEA more like land cover types, which are added to and reduced by area through managed/natural expansion/ regression.

- In **Table 1** "individual environmental assets" are non-ecosystem assets, such as minerals or aquatic resources as defined in the SEEA-CF. Ecosystems are accounted for in terms of area (Although there has been some discussion of accounting for ocean ecosystems in terms of volume) of ecosystem types (ETs). Individual environmental assets are measured in units specific to the asset (tonnes, m^3, etc.). Reasons for additions and reductions are also different for each individual asset, depending on whether it is living and/or mobile. **Table 1** could be expanded to include many ecosystem types and many individual assets (e.g., distinguishing different species of fish, crustaceans, molluscs, seaweeds, etc.).
- It is possible to attribute monetary values to some ocean assets. Monetary Ocean Asset Accounts are described in **Monetary Asset Accounts**.
- There are no agreed condition indicators for all asset types. Ecosystems can be generally assessed in terms of their biodiversity, productivity, levels of pollutants, etc. Individual environmental assets each require their own indicators of condition. Minerals may be high or low quality, accessible or inaccessible. Fish may be assessed in terms of health or age of the stock.
- **Table 2** provides a structure for reporting the summary of condition measures for ocean assets. As with extent, this would be built up from more detailed tables on the location of individual ecosystem or individual assets, condition measures over time (e.g., degree heating weeks based on sea surface temperature), and more complex source measures (e.g., distances of specific assets from population centres). This could then be summarized over ecosystem types and individual environmental asset types as in **Table 3**.

Table 2. Physical Asset Condition Account by MBSU for each depth layer at end of accounting period

	Variable Examples	**Ecosystem assets**			**Individual environmental assets**	
		Mangroves	Seagrass	Coral reef	Minerals	Fish stocks
Area	ha					
Acidification	pH					
Eutrophication	BOD, COD, Chlorophyll-A					
Temperature	℃					
Plastics	g/m^3					
Quality	Appropriate measure					
Accessibility	km from population centre					
Biodiversity	Shannon Index					
Health	Index					
Repeated for end of accounting period						
Repeated for change in condition						

Notes: This Physical Asset table can be combined with other Tables that record information for each Spatial Unit in the accounting framework, for example **Table 16** on governance.

- Condition accounts in the SEEA Ecosystems revision discussions distinguish between "variables", which are summaries of basic measures and "indicators", which are the same measures indexed according to a reference condition. A reference condition could be a condition measured or estimated for the past or an "ideal" condition determined by scientific consensus.
- There also is an ongoing discussion within the SEEA Ecosystems revision process regarding the treatment of biodiversity within the ecosystem accounting framework. Further, the aspiration that such tables can be

produced for different depth layers is optimistic in that standard spatial techniques for managing and summarizing such data have not yet been developed.

The ESCAP China Ocean Accounts Pilot developed asset accounts for the Beihai Bay for mangroves (area and biomass), sediment and seawater nutrients (carbon, nitrogen, phosphorous), marine living resources (crab, fish, birds) and marine freshwater resources (river, rainwater and groundwater influx). https://www.unescap.org/sites/default/files/1.3.A.1_China_GOAP_12-15Nov2019.pdf

Table 3. Summary Asset Condition Account by ecosystem type and individual environmental asset type at end of accounting period

indexed with respect to reference condition	**Indicator Examples**	**Reference level**	**Ecosystem assets**			**Individual environmental assets**	
			Mangroves	Seagrass	Coral reef	Minerals	Fish stocks
Area	ha						
Acidification	pH						
Eutrophication	BOD, COD, Chlorophyll-A						
Temperature	°C						
Plastics	g/m^3						
Quality	Appropriate measure						
Accessibility	km from population centre						
Biodiversity	Shannon Index						
Health	Index						
Repeated for end of accounting period							

Repeated for change in condition

2.3.5 Monetary asset accounts

- Not all assets can be properly represented in monetary terms. In general, the monetary value of an asset, whether it is an ecosystem or individual environmental asset, can be defined as the Net Present Value (NPV) of expected future flow of services from that asset (See SEEA-CF Chapter V). For individual environmental assets, such as minerals, harvested fish or timber, there is a market price and therefore the flow of services can be measured as the "rent", or difference between the cost of production and the market value of the product. Some ecosystem services, such as carbon sequestration, have established "prices" and can be treated similarly. This requires appropriate valuation of the services derived from these assets.
- However, the true "value" of ecosystem services is often embedded in long-term ecological integrity (such as coastal protection or soil formation) or cultural preferences (such as culturally significant seascapes). However, many thousands of studies have "valued" these services in monetary terms, often using methods that are not coherent with standard economic accounting. That is, standard economic accounting focuses on exchange values, whereas many valuation methods focus on the welfare values, which are benefits derived from the consumption of the services. This is discussed further in **Assessing supply and use of ocean services**.
- For the purposes of ocean accounting, it is suggested that monetary asset accounts be based on monetary valuation of market services (SNA-benefits). The future flow of other ecosystem services (non-SNA-benefits) can be represented in physical terms, for example, meters of coastline protected from erosion, hectares of fish breeding habitat, or kilograms of phosphorous assimilated.
- The monetary asset account (**Table 4**) for those assets whose services can be valued in monetary terms follow the structure of the physical asset accounts: opening stock, additions, reductions and closing stock.
- The monetary asset account is built up from information on the flows of ocean services (see **Flows to the Economy**). For example, the physical asset accounts can also be used to estimate future additions (natural growth) and removals (harvesting, natural losses, catastrophic losses) from a commercial fish stock species. Given this estimate of future fish stocks, and assumptions about the cost of production and future prices, the value of the future flow of services can be estimated. These assumptions, as well as the chosen future period and discount rate will have large effects on the estimates of asset value.
- Future flows can be based on current levels of production or natural additions and reductions. However, it may be more realistic to base future flows on agreed alternative scenarios (such as comparing "business as usual" with increased mangrove restoration or decreased pollution levels). This would provide a range of estimates that could be adjusted as conditions change and information improves.
- However, showing monetary asset accounts alone may focus undue attention on the SNA-benefits (often short-term) they are based on, while detracting from the many important non-SNA-benefits.
- Monetary valuation of ecosystem assets for accounting purposes is a key focus of the SEEA revision process. A recent discussion paper (Fenichel and Obst 2019) makes detailed methodological recommendations for ecosystem asset valuation inclusive of ocean ecosystems, concluding that welfare-based measures of change can provide input prices for observed quantities of environmental goods and natural and ecosystem assets. These can be combined with index number theory to derive appropriate nominal prices for inclusion in accounts, if they are measured at broad enough scales.
- Developing a comprehensive view of monetary asset accounts, one that includes the future flows of SNA and non-SNA benefits, is essential to understanding the true wealth of our ocean assets (See **Ocean Wealth**). For example, the placement of tangible dollar values on ecosystem assets in the Kenyan mangrove restoration project. Testing these types the new approaches currently being developed will be a topic for future research.

Table 4. Monetary Asset Account (currency units)

	Ecosystem assets			**Individual environmental assets**		**Total**
	Mangroves	Seagrass	Coral reef	Minerals	Fish stocks)	
Opening stock						
+ Additions to stock						
Managed expansion						
Natural expansion						
Reclassifications						
Discoveries						
Reappraisals (+)						
TOTAL additions to stock						
– Reductions in stock						
Managed regression						
Natural regression						

Reclassifications						
Extractions						
Reappraisals (-)						
TOTAL reductions in stock						
Re-valuation of stock						
= Closing stock						
Measurement Units	*Monetary*	*Monetary*	*Monetary*	*Monetary*	*Monetary*	*Monetary*

2.4 Flows to the economy (supply and use accounts)

2.4.1 Defining flows to the economy

- The economy and other human activities depend on flows from ocean assets. Natural inputs from individual environmental assets are extracted, harvested, captured, whereas services from ecosystem assets are "enjoyed, consumed or used" (Boyd and Banzhaf, 2017) providing benefits to people. These flows of ocean services can be recorded in Ocean Accounts in physical and monetary terms following the principles explained in the SEEA–CF, SEEA–EEA, and SNA. Ocean accounting requires distinguishing these flows, as it does with distinguishing the assets, that are relevant to the ocean.

2.4.2 General classification of flows to the economy (ocean services)

- Flows of ocean services to the economy are divided into four categories, combining the SEEA–CF and SEEA–EEA concepts of flows:
    - SEEA-CF natural inputs (often considered "commodities" or "goods")
    - **Materials:** including minerals and energy resources, soil, timber, aquatic resources, and other biological resources;
    - **Energy:** including inputs of energy from fossil fuels, solar, hydro, wind, wave and tidal, geothermal, and other electricity and heat;
    - **Water:** including surface water, groundwater, soil water and seawater.
    - SEEA-EEA ecosystem services (provisioning, regulating and maintenance, cultural)

  - **Ecosystem services:** defined as the contributions of ecosystems to benefits to economic and other human activity.
- Natural inputs from the environment, as defined by the SEEA-CF are physical quantities of goods that are extracted, harvested or captured and then supplied to users. The Ocean Accounts Framework applies the same concepts and definitions but suggests distinguishing between natural inputs that are taken from the ocean from those that are taken from land or freshwater areas. For example, the physical supply and use of energy (SEEA-CF Table 3.5) could further distinguish energy supplied from coastal and marine areas (offshore oil and gas, wave, tidal, wind, etc.).
- Natural inputs are well defined in the SEEA-CF and, other than distinguishing those flowing from the ocean, there is no further guidance on their treatment for Ocean Accounts. Ecosystem services, however, bear further discussion, given the variety of definitions and applications used.

2.4.3 Classification of ocean ecosystem services

- Ecosystem services, while overlapping somewhat with natural inputs for provisioning services, are quite different for regulating and cultural services. Many ecosystem services, such as “recreation” are not physical flows, but other types of transactions (enjoying, appreciating, valuing, etc.).
- Each of these services are supplied by an economic unit, whether a corporation, government or household. Many market services can be associated with the industry sector supplying them and would appear in the production statistics of those sectors. For non-market ecosystem services, the supplier or user is generally considered to be the owner of the asset. Beneficiaries, as in the case of carbon sequestration, may be in the same location or far away.
- Ecosystem services often mentioned in ocean ecosystem service assessments (adapted from Bordt and Saner, 2019) include:
  - Provisioning
  - Biomass for nutrition (cultivated and wild animals, plants, algae or fungi)
  - Biomass for materials (cultivated and wild animals, plants, algae or fungi)
  - Genetic materials from plants and animals (pharmaceutical products, genetic inventorying and conservation)
  - Abiotic materials and energy (offshore oil and gas, minerals; wind, wave, solar energy)
  - Abiotic: substrate for transportation
  - Abiotic: seawater for drinking (desalination) or non-drinking (industrial cleaning and cooling)
  - Regulating and maintenance
  - Lifecycle maintenance and habit protection (e.g., fish breeding habitat, habitat for iconic species)
  - Mediation of wastes by estuaries (dilution, filtration)
  - Mediation of mass and liquid flows by mangroves, coral reefs, seagrasses, estuaries, rocky shores (coastal protection from erosion and waves)
  - Atmospheric composition and conditions (carbon sequestration by mangroves, coral reefs, seagrasses, tidal marshes)
  - Cultural
  - Physical and experiential interactions
  - Intellectual and representative interactions
  - Symbolic significance of beaches and open ocean
- Further examples are provided in **Appendix 6.3.** Future research would be required to inventory ocean-related ecosystem services and associate them with appropriate ocean assets.
- A list of common, widely applicable ecosystem services is under development as part of the SEEA Ecosystems revision process. The list, as of mid-2020. is described below (**Table 5x**):

Table 4a. List of common, widely applicable ecosystem services is under development as part of the SEEA Ecosystems revision process

Ecosystem service		**Relevance to Ocean Accounts**
Provisioning services		
Biomass provisioning services	Crop provisioning services	applies to cultivated crops, mangroves and other non-fish provisioning in intertidal areas
	Grazed biomass provisioning services	
	Timber provisioning services	
	Non-timber forest products (NTFP) and other biomass provisioning services (incl. those related to hunting and trapping and bio-prospecting activities)	
	Fish and other aquatic products provisioning services	including from coastal aquaculture and capture fisheries and marine fisheries)
Water supply (Purification and regulation)		may apply to mangroves, tidal flats, estuaries and coastal vegetation in terms of purifying inland water flows to the ocean
Genetic material services		Applies as well to materials supplied from coastal and marine ecosystems.
Regulation and maintenance services		
Global climate regulation services		Including carbon sequestration and storage by phytoplankton, mangroves, and seagrasses
Rainfall pattern regulation services (at sub-continental scale)		intended for tropical forests, but ocean temperature and cycles will contribute substantially

Local (micro and meso) climate regulation services		also intended for terrestrial, but applicable to coastal ecosystems (especially mangroves).
Air filtration services		including by mangroves, coastal vegetation
Soil quality regulation services		decomposition of biological materials also occurs in marine ecosystems.
Soil erosion control services (includes also sediment retention services)		applies to flood protection by mangroves, coral reefs and seagrasses
Water purification services (water quality amelioration)	Retention and breakdown of organic pollutants including excess nutrients	may apply to mangroves, tidal flats, estuaries and coastal vegetation in terms of purifying inland water flows to the ocean
	Retention and breakdown of inorganic pollutants	
Water regulation services	Baseline flow maintenance	applies to flow/wave regulation by mangroves, coral reefs and seagrasses
	Peak flow mitigation	
Flood mitigation services	Seawater (Tidal) surge mitigation (Coastal protection services)	applies to flood protection by mangroves, coral reefs and seagrasses
	River flood mitigation	
Storm mitigation services		applies to storm mitigation by coastal ecosystems
Noise attenuation services		may apply to mangroves, coastal dunes
Pollination services		gamete dispersal in marine environments
Pest control service		applies to coastal and marine ecosystems

Nursery population and habitat maintenance services		applies to coastal and marine ecosystems
Solid waste remediation		applies to coastal and marine ecosystems
Cultural services (may be renamed non-material services)		
Recreation-related services	Tourism recreation-related services	applies to coastal and marine ecosystems
	Local recreation-related services	
Amenity services		applies to coastal and marine ecosystems
Education, scientific and research services		applies to coastal and marine ecosystems
Spiritual, symbolic and artistic services		applies to coastal and marine ecosystems
Local and community use (including indigenous values)		applies to coastal and marine ecosystems
Ecosystem and species appreciation services		applies to coastal and marine ecosystems

- One topic that requires further research is linking ecosystem processes (sometimes called "intermediate" services) with the ecosystem service classification. An ecosystem process, such as primary productivity, will contribute to many services (biomass generation, carbon sequestration, water regulation), but not be "directly used, consumed or enjoyed" by people. A better understanding of how these processes support services can lead to improved measures of ecosystem condition and capacity.

2.4.4 Physical flow (supply and use) accounts

- Physical flow tables (aka physical supply and use tables or PSUTs) trace the physical transactions between supplier and user. The SNA traces some of these transactions between economic units in monetary terms, but the SEEA adds physical flows and acknowledges the environment as the "first supplier" of natural inputs to the economy. This adds a powerful perspective in that natural inputs can be traced from extraction, harvesting or capture to their transformation into products, exchanges between users and eventually to final consumption and release to the environment as residuals.
- Tracing through the general supply and use table (**Table 5**), taking for example aquatic resources, the environment supplies tonnes of fish to the fishing industry, which is the "first user". The fishing industry may have losses in capture (bycatch), transportation or storage, the remainder of which may be supplied as "products" directly to markets or as intermediate products to the food processing industry. Additional

products may be supplied by the "Rest of the World" as imports and in combination with domestic products are supplied to the final consumer or to the "Rest of the World" as exports. At each stage, losses are recorded as waste products, which may be reused or recycled, or waste residuals, which are accumulated in landfill or flow to the environment.

- Accounting principles and the structure of the tables help ensure that the accounts balance. For example, the total *supply* of natural inputs must equal the total *use* of natural inputs. This helps estimating missing data. For example, one data source may specify the total supply and another the use by some sectors. The difference can be allocated to the missing sectors. Putting both supply and use into the same account helps trace the flows from one stage to the other. For example, if more is supplied than used, there may be a loss in transformation or transmission.
- While this table describes the flows of an ocean service, it the same structure is used to trace the flows of non-ocean natural inputs that may eventually flow to the ocean. Physical water supply and use accounts can indicate the amounts of wastewater released to the environment. Much of the wastewater released to surface water will eventually flow to the ocean. Accounting for water supply and use at the drainage basin level can provide an indication of the geographic and sectoral source of excess nutrients flowing to the ocean. Likewise, physical material and energy flow accounts can provide similar insights on the destination of biomass, minerals, and energy product residuals. This is discussed further in **Flows to the Environment** (residuals).

Table 5. Flows table: General supply and use table (physical or monetary) (during accounting period)

Physical or monetary units	Industries (and govt)	Households	Accumulation	Rest of the World	Ocean Services (From Environment)	Total
Supply table						
Ocean services					Flows to economy from ocean assets (including ecosystem services)	*Total supply of ocean services*
Products	Output			Imports		*Total supply of products*
Flows to the environment (residuals)	Output flows generated by different industry sectors	Output flows generated by final household consumption	Output flows from scrapping and demolition of produced assets			*Total supply of residuals*

Use table						
Ocean services	Extraction, harvesting or capture of natural inputs	*				*Total use of ocean services*
Products and services	Intermediate consumption	Household final consumption	Gross capital formation	Exports		*Total use of products*
Flows to the environment (residuals)	Collection and treatment of waste and other residuals		Accumulation of waste in controlled sites		Flows to environment (of which direct to the ocean)	*Total use of residuals*

Note: Dark grey cells are null by definition. In this case, ocean services flow from the environment. Natural inputs are used by the economic sector that extracts, harvests or captures them.

- In practice, households supply many of their own services from Ocean Assets (e.g. subsistence fishing, collection of firewood). To maintain compatibility with the SEEA and the broader integrity of the accounts, natural inputs must first be supplied by an industry sector. Consequently, the cell marked with an asterisk (*) is null by definition, since for supply purposes, households are included in the industry supplying that natural input (fishing, energy).
- Note that in **Table 5,** the row for supply of "Ocean Services" is greyed out other than for the column "Ocean Services (From environment)". This cell could show an aggregate monetary amount or be detailed in terms of physical quantities for each service. The physical quantities would include all natural inputs including fish captured, minerals extracted, and other services supplied.
- Physical quantities of natural inputs extracted, harvested or captured are generally not as well recorded as the monetary value of those inputs. However, in many countries, quantities of fish catch, aquaculture production, or timber harvesting are reported in administrative records or sample surveys. Income from these activities is more likely to be reported, since this is required to estimate the value of production in the SNA and to calculate taxes. Knowing the total value and price of a given commodity (e.g., dollars per kg of fish) allows the estimation of the physical quantities (e.g., kg of fish). This applies equally to minerals, timber, water, fish, crops and livestock.
- **Ocean economy satellite accounts** record the economic performance of ocean-related industry sectors. Production statistics used to establish this performance would also include data on the quantity and value of natural inputs supplied. Reconciling the services perspective of the SEEA with the sectoral perspective of the ocean economy satellite accounts is an item for future research.
- Although the SNA, in theory, captures small-scale industry and subsistence household supply of natural inputs, they are sometimes missed in economic surveys. Some countries have conducted special surveys to capture this detail. For example, UN Environment augmented Ethiopia's SNA with a household survey to determine the importance of forest ecosystem services to rural households. This resulted in an increase of the estimated contribution of forests to GDP from 3.8% to 6.1%. Statistics Canada added questions to its biannual Households and the Environment survey to determine the quantities of residential fuelwood consumed. Although the objective was to estimate air emissions, it also provides a potential for calculating the market value of the wood. Fisheries and Oceans Canada conducts a Survey of Recreational Fishing in

Canada, which captures the number of anglers, the quantities of fish caught and related expenditures. The U.S. Forest Service periodically conducts a national survey of outdoor recreation, which is the basis for the outdoor recreation satellite account. In the U.S., there are also national surveys of recreational fishing, which are used to add recreational fishing effort into fisheries management planning.
- Efforts by the International Institute for Environment and Development (IIED) have led to a survey and toolkit which examines the subsistence and recreational supply of ocean- related natural inputs, relevant to small scale fisheries in national accounts. Other efforts include the Environmental Defense Fund's work on community-level fisheries in Baja California, Mexico since 2015 to create satellite fishery accounts for remote fishing villages.
- The SEEA-CF presents separate supply and use tables for each natural input, such as water, energy and individual materials. This allows for representing the full set of flows from environment (first supplier) to first user (economic units extracting, harvesting or capturing), transformation into products, consumption of those products and eventual release back to the environment as residuals. Regarding this as a multi-stage supply-use chain (supplier to user, user becomes supplier to new users) helps enforce the accounting principles that "supply equals use". That is, the total supply of natural inputs equals the total use of natural inputs. This requires unique units of measure for each table, such as tonnes of fish, m^3 of water. PJ of energy or dollars. For this reason, the SEEA-CF maintains separate tables for each natural input.
- SEEA-EEA presents the supply and use of ecosystem services provided by each ecosystem type. Some provisioning services can be traced from supplier to user as "materials" as in the SEEA-CF but regulating and maintenance and cultural services are not obvious direct inputs to production processes. The Ocean Accounts Framework merges the two perspectives, but this would result in a very complex table.
- For the Ocean Accounts, it would also be practical to keep separate tables for each ocean service. That is, separate tables for fish of different types, energy, water, materials, etc. as in the SEEA-CF (SEEA-CF Tables 3.5 and 3.6) as well as for each ecosystem service. The structure in **Table 5** could then be used as a summary.
- To link to asset information (extent and condition of different ecosystem types), spatial information on the location of the supply of these ocean services could be recorded in the underlying spatial database.
- A separate table, then could also be constructed summarizing the supply of all ocean services (including abiotic), as in **Table 6**. For simplicity, this is shown without the implied transformation into products and eventual release to the environment as residuals. As with the generic supply and use in **Table 5**, services are initially supplied by the environment, but used by many economic units. Businesses, governments, households, and the "rest of the world" (exports). In an actual table, industries would be detailed by sectors relying most on ocean services. For example, the coastal and marine tourism industry may be dependent on water purification, coastal protection, habitat provision, amenity and recreation services.
- Quantifying these dependencies, though further research, would contribute to the creation of "economic production functions". That is, detailing the inputs required by an economic sector including ecosystem services in physical and monetary terms. This is further discussed in terms of valuation of ecosystem services in **Monetary Flow**.

Table 6. Flows to the economy: Supply and use of ocean services (physical or monetary) (during accounting period)

Physical or monetary units	Industries (and government)	Households	Accumulation	Rest of the World	Ocean Services (by Ecosystem Type or Spatial Unit)			**Total**
					Mangrove	Coral	Open marine	
Supply table								

Provisioning services					(See Table 7 for details)	
Regulation and maintenance services						
Cultural services						
Abiotic services						
Use table						
Provisioning services						
Regulation and maintenance services						
Cultural services						
Abiotic services						

Note: Dark grey cells are null by definition. In this case, the environment provides the services and economic sectors use them.

Table 7. Examples of ocean services by ecosystem type

Type of service (per year)	**Ecosystem type**			
	Mangrove	Coral	Seagrass	Open marine
Provisioning	Timber (tonnes)	Fish catch (tonnes)	Seagrass (tonnes)	Fish catch (tonnes)

Regulating	Carbon sequestration (T), Coastal protection (ha)	Carbon sequestration (T), Fish habitat (ha), Coastal protection (ha)	Carbon sequestration (T), Fish habitat (ha), Coastal protection (ha)	Oxygen production (T)
Cultural	Tourism (visitors)	Tourism (visitors)	Scientific (researchers)	Existence (importance)
Abiotic	Seawater for cooling (m^3)	Sand (tonnes)		Petroleum (mega litres)

The UK Joint Nature Conservation Committee (JNCC) and Centre for Environment, Fisheries and Aquaculture Science (Cefas) in their initial set of *Natural Capital Accounts for UK Marine and Coastal Ecosystems* (heretofore referred to as the UK pilot) found that 36% of the marine habitats were unknown. Of those that were known, they assessed the value of waste (Phosphorous, Nitrogen, BOD) mediation by Littoral sediments, Coastal saltmarsh, Shelf-sea, Deep-sea, Coastal dunes and Sandy shores based on cost avoided to provide the same treatment. They also assessed the value of coastal protection in terms of the cost of providing equivalent protection by constructing seawalls, and the value of carbon burial at the abatement cost of non-traded carbon. They further assessed the value of marine fish and shellfish, renewable energy (wind) and abiotic products (aggregates) using the resource rent approach. (Thornton et al., 2019)

2.4.5 Monetary flow (supply and use) accounts

- Monetary flow accounts follow the same structure as the physical flow accounts. The SEEA-CF provides guidance on assessing the economic value of natural inputs. Ecosystem services, however, cover a broader range of benefits and require different methods, often unique to each service.
- The benefits of ocean ecosystem services are not always well represented in economic terms. therefore, monetary flows are often best considered a “low estimate”. This is especially true for non-market ecosystem services. That is, the full value to society of the service is always higher than the monetary estimate.
- There is an extensive literature on ecosystem services valuation. However, many methods are not compatible with established national accounting and other statistical principles. The SEEA Ecosystems revision process has suggested three levels of methods (undisputed/preferred, conditional, rejected) (**Table 8**) and three tiers of ecosystem services valuation methods depending on data availability and technical capacity (**Table 9**). See **Assessing extend and condition of ocean assets** for a short description of some of the main methods.
- Whether the valuation methods suggested in the SEEA Ecosystems revision process, such as production functions, will satisfy the requirements for compiling monetary flow accounts for all ocean services is a matter for further research. This is also discussed in terms of consolidating the services approach of the SEEA with the activity approach used in ocean economy satellite accounting in **Reconciling activity and service approaches**.

Table 8. A, B and C methods for ecosystem services valuation

A method	Undisputed/preferred	production function; hedonics; simulated exchange value; environmental protection expenditure in combination with opportunity costs of land; Marginal Value Pricing; avoidance costs (least cost alternatives iff < WTP); quota/leases
B method	Conditional	resource rent; benefit transfer using meta-regression models
C method	Rejected	restoration costs; market prices (for crops); travel costs (in case only direct costs); stated preference (with CS); unit value transfer without adjustment

Note: iff < WTP means "if and only if avoidance cost is less than Willingness to Pay"

Table 9. Tiered approach to valuation of ecosystem services approaches

Category	Service	Tier 1 (data poor/ low technical capacity)	Tier 2 (moderate data/technical capacity)	Tier 3 (data rich/ high technical capacity)
Provisioning	Crops	Fraction of market price*	Leases/resource rent**	Production function
	Timber		Stumpage value	
	Fish		Resource rent	Quota/permits
	Water	(Recommended not to be seen as a provisioning service)*****		
Regulating	Carbon sequestration	Social cost of carbon	Social cost of carbon	Emission trading schemes
	Soil retention	Benefit transfer	Avoided costs (any)	Avoided costs (least cost alternatives iff < WTP)
	Air filtration			

	Water purification			
	River flood regulation			
	Coastal flood regulation			
	Water flow regulation			
Cultural	Tourism	Fraction of tourism revenue spatialized based on accommodation	Fraction of tourism revenue spatialized based on accommodation	Fraction of tourism revenue spatialized based on geotagged social media data
	Nearby use (e.g., recreation)	Benefit transfer	Simulated exchange value*** / Protection expenditures + opportunity costs of land	Simulated exchange value (intersection of supply and demand curve)
	Adjacent use (e.g., as reflected in property value)	Expert estimates of premium	Hedonic pricing (survey data – small sample)	Hedonic pricing (property sales data – large sample)****

Notes: * e.g., applying a single fixed percentage based on a research study across all estimates

** Resource Rent approach also covers some income less costs methods

***using the 50% median approach

**** Marginal Value Pricing potentially (few applications so far)

***** Water is not the result of ecosystem processes; therefore, water supply may better be seen as an abiotic service (editor's note).

2.5 Flows to the environment accounts (residuals)

2.5.1 Defining and classifying flows to the environment

- The SEEA-CF (para 2.92) defines residuals as "flows of solid, liquid and gaseous materials, and energy, that are discarded, discharged or emitted by establishments and households through processes of production, consumption or accumulation". Although there is no international standard classification of such residuals, the SEEA-CF provides guidance on accounting for returns of wastewater (in water supply and use accounts), air emissions (including CO_2 from fossil fuel consumption, water emissions and solid wastes (including plastics and hazardous wastes).

- The Ocean Accounts Framework suggests estimating residual flows that flow to the ocean, whether from terrestrial, inland water, coastal or marine sources. Air emissions are diffuse and contribute generally to atmospheric conditions rather than to local ocean conditions. Other residuals accounts, namely water supply and use (for wastewater), water effluents and solid waste accounts can be estimated by drainage basin (See for example, Statistics Canada. 2016. Human Activity and the Environment: Freshwater in Canada) and provide an indication of the geographic and sectoral source of residuals flowing to the ocean.
- Section 3.5 in the SEEA-CF details accounting for the supply and use of water. Water Supply and Use Accounts describe the flows of water, in physical units, from initial abstraction from the environment, supply to the economy, use by industries and households, reuse and eventual discharge to the environment. This includes the use of seawater, either after desalination for domestic consumption or saltwater used in industrial processes. By compiling Water Supply and Use Accounts at the drainage basin level, it is also possible to estimate flows of wastewater to the ocean. The quality of the wastewater may range from treated, and therefore potable, to untreated. Linking these to water emission accounts (see below) would help understand the potential impacts of wastewater on ocean water quality. This Guidance does not provide additional detail on producing Water Supply and Use Accounts.
- Section 3.6.3 in the SEEA-CF details accounting for air emissions. The substances recorded in Air Emissions Accounts are: CO_2, methane, N_2O, NO_x, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride, carbon monoxide, non-methane volatile organic compounds, sulphur dioxide, ammonia, heavy metals, persistent organic pollutants, and particulates, including PM_{10}, $PM_{2.5}$ and dust. Each of these substances have different effects on the climate and human and ecosystem health, including through dispersion into the ocean. This Guidance does not provide additional detail on producing Air Emissions Accounts for the ocean. However, it is suggested to allocate national air emissions to ocean economic activities to monitor policies such as zero carbon marine shipping.
- Section 3.6.4 in the SEEA-CF details the supply (generation) and use (disposition) of water emissions. Water Emissions Accounts record substance released directly by industries and households, including substances released by the sewerage sector after treatment. Substances suggested to be included in Water Emissions Accounts (see below) are: BOD/COD, suspended solids, heavy metals, phosphorous and nitrogen. Some proportion of these substances will flow to the coastal and marine ecosystems.
- Section 3.6.5 in the SEEA-CF details the supply (generation) and use (disposition) of solid wastes including hazardous wastes. Solid wastes are generated from many sources (including industries, households, landfills and imports), collected, recycled, reused, accumulated in controlled landfill, exported and discarded directly to the environment. Therefore, Solid Waste Accounts (see below) can be more complex than other residual flows. For example, at any stage of collection, treatment, transformation or transportation, losses to the environment can occur. Compiling Solid Waste Accounts at the drainage basin level and recording the location of landfills will support estimating the quantities of solid wastes that are deposited in the ocean.
- There is no international classification of solid wastes. The SEEA-CF draws illustrative examples from the European Waste Classification for Statistics (EWC-Stat) (Eurostat, 2010). Solid wastes most often included in Solid Waste Accounts are: chemical and health-care waste, radioactive waste, metallic waste, non-metallic recyclables, discarded equipment and vehicles, animal and vegetal wastes, mixed residential and commercial wastes, mineral wastes and soil, combustion wastes and other wastes. Wastes of specific concern to the Ocean Accounts, such as plastics, can be disaggregated from this general classification.

2.5.2 Physical flow accounts (to the environment)

ⓘ The UK pilot estimated the amounts of nitrogen, phosphorous and BOD discharged from wastewater treatment plants close to the coast. (Thornton et al., 2019)

The Vietnam ESCAP Ocean Accounts Pilot estimated the quantities of COD, BOD_5, Total Nitrogen, Total Phosphorous, Nitrites and Nitrates, Ammonium, Phosphate, and Total Suspended Solids generated from coastal tourism based on per capita figures reported in the literature.
https://www.unescap.org/sites/default/files/1.3.A.5_Viet%20Nam_GOAP_12-15Nov2019.pdf

- The general physical supply and use table shown in the SEEA-CF (adapted as **Table 5**, above) shows the logic of all physical flows from extraction, harvest or capture from the environment to transformation and use, and finally to accumulation and disposition in the environment. As with flows to the economy, the challenge in adapting flows to the environment for Ocean Accounts is to distinguish residuals that flow to the ocean.
- Countries with existing accounts for water, air emissions, water emissions, or solid wastes can estimate these residuals by drainage basin. For example, an initial estimate of solid waste generation by drainage basin could attribute similar solid waste generation rates, composition and collection rates to all households and estimate drainage basin amounts on the number of households in each area. This is further elaborated in **Assessing pollutants**.
- **Table 10** shows the **supply** (generation) of water emissions consisting of direct emission and release to other economic units (e.g., the sewerage industry) by drainage basin, for land-based sources and by marine area (for marine-based sources). The **use** part of the tables shows the parallel "use" in terms of flows to the environment and collection by other economic units.

Table 10. Basic structure for Water Emissions Account by drainage basin and marine area

Physical supply (generation) table for gross releases of substances to water										
Source area	Substance	Industry					Households	Flows from the environment		Total supply
		Sewerage industry	Agriculture	Mining	Marine transport	Other		Total	Of which from ocean	
Direct emissions										
Drainage basin 1	BOD/ COD	*D*	*A*							*E*
	Suspended solids									
	etc.									
Marine area 1	Bilge									

	Heavy metals									
	Etc…									
etc.										
Releases to other economic units										
Drainage basin 1	BOD/ COD		*B*							*C*
	Suspended solids									
	etc.									
Marine area 1	Bilge									
	Heavy metals									
	Etc…									
etc.										

Physical use table for gross releases of substances to water

Source area	Substance	Industry					Households	Flows to the environment		Total use
		Sewerage industry	Agriculture	Mining	Marine transport	Other		Total	Of which to ocean	
Direct emissions										

Drainage basin 1	BOD/ COD							*E*	*EO*	*E*
	Suspended solids									
	etc.									
Marine area 1	Bilge									
	Heavy metals									
	Etc…									
etc.										
Collection by other economic units										
Drainage basin 1	BOD/ COD	B								*C*
	Suspended solids									
	etc.									
Marine area 1	Bilge									
	Heavy metals									
	Etc…									
etc.										

ⓘ The Samoa ESCAP Ocean Accounts pilot estimated the quantities of solid waste generated by tourism by applying tourism factors from the test tourism satellite account to the same industries in the pilot Samoa waste account.

https://www.unescap.org/sites/default/files/1.3.A.3_Samoa_GOAP_12-15Nov2019.pdf
The Thailand ESCAP Ocean Accounts pilot estimated total waste generated in the study area and allocated a portion to tourism based on known per capita factors. That is, tourists generated almost four times the waste of residents.
https://www.unescap.org/sites/default/files/1.3.A.4_Thailand_GOAP_12-15Nov20199.pdf

Note: See Table 3.8 in the SEEA-CF. “Other” industries could include for example aquaculture and coastal tourism. “Releases to other economic units” are emissions to the sewerage industry. “Direct emissions” are releases to the environment including those released by the sewerage industry. For example, agriculture releases BOD quantities in Drainage basin 1 in the amounts of *A* directly to the environment and *B* to the sewerage industry. This is recorded as *C* in total supply of releases to other economic units. The sewerage industry removes all but *D*, which is added to *A* directly released by agriculture to *E*, which is the total direct emissions. *E* is also the total released to the environment and total use of direct emissions. *EO* is the proportion estimated to flow to the ocean.

- Supply and use of solid wastes (**Table 11**) are more complex, since several industries not only generate solid wastes, but also use them as products in recycling, incineration and landfill. The table shows detail by location of generation and use of waste residuals and could be expanded to include many more substances. In the “use” part of the table, solid waste residuals disposed of in the environment are distinguished by those flowing directly to the ocean.

Table 11. Physical supply and use of solid waste residuals

Physical supply of solid waste residuals											
Source area	Substance	Generation of solid waste							Rest of the world	Flows from the environment	Total supply
		Landfill	Incineration		Recycling and reuse	Other treatment	Other industries	Households	Import of solid waste	Recovered residuals	
			Total	Of which used to generate energy							
Generation of solid waste residuals											
Drainage basin 1	Chemical and health care waste										

	Radioactive waste										
	Metallic waste										
	Mixed residential and commercial waste.										
Drainage basin 2	Mineral waste and soil										
	Other waste										
Marine area 1	Mineral waste and soil										
	Other waste										
etc.											
Generation of solid waste products											
	Chemical and health care waste										

	Radioactive waste										
	Metallic waste										
	Mixed residential and commercial waste.										
	Mineral waste and soil										
	Other waste										

Note: Dark grey cells are null by definition. Solid waste products are solid wastes that are discarded but resold by other industries. The table could further distinguish quantities recovered from the ocean. Ideally, the table would also distinguish the generation and use of solid waste products spatially. This would allow tracing flows of reused/recycled materials between spatial areas and eventually to the ocean.

Table 11. Physical supply and use of solid waste residuals (continued)

Physical use of solid waste residuals											
Source area	Substance	Intermediate consumption					Final consumption	Rest of the world	Flows to the environment		Total use
		Landfill	Incineration	Recycling and reuse	Other treatment	Other industries	Households	Exports of solid waste	Total	Of which to Ocean	

			Total	Of which used to generate energy								
Collection and disposal of solid waste residuals												
Drainage basin 1	Chemical and health care waste											
	Radioactive waste											
	Metallic waste											
	Mixed residential and commercial waste.											
Drainage basin 2	Mineral waste and soil											

	Other waste											
Marine area 1	Mineral waste and soil											
	Other waste											
etc.												
Use of of solid waste products												
	Chemical and health care waste											
	Radioactive waste											
	Metallic waste											

	Mixed residential and commercial waste.											
	Mineral waste and soil											
	Other waste											

Note: Solid wastes are collected, sent to landfill, incinerated, sent to treatment, used by other industries, exported or discarded to the environment. Solid waste products are used by recycling, other treatment, other industries or exported.

- **Table 12** below summarizes air emissions, water emissions, wastewater and solid wastes flowing to the ocean. Ideally, the table shows the sector and drainage basin of the source. It records the estimated flows from sources that could potentially enter the ocean environment. For example, in the case of greenhouse gas emissions — the estimated emissions absorbed / buffered by oceans. The table could be combined with accounts of flows to the environment as a whole, to provide an integrated presentation of flows entering the ocean versus other environmental sinks. The link between flows to the environment and condition is difficult to establish due to time lags and complex dispersion factors. However, tracking the quantities generated and where they are generated will help understand the source of residuals existing in the ocean.

Table 12. Supply of flows to the ocean (physical) (during accounting period)

By source area (e.g. drainage basin, country)	Industries			Households	Rest of the World	**Total**
	Agriculture	Mining	Other			

Air emissions (tonnes) CO_2 Methane […]						
Water Emissions (tonnes) BOD/COD Suspended solids […]						
Wastewater (m^3)						
Solid Wastes (tonnes) Plastics Animal and vegetal wastes […]						

2.6 Ocean economy satellite accounts

- Ocean economy satellite accounts record the economic performance of ocean-related industry sectors. The term "ocean economy satellite accounts" is intended to reflect an agreed approach that supersedes the many already in use. Since these existing approaches use different data sources, classifications and methods, they are difficult to compare. Furthermore, it is a challenge to provide a single source of guidance on how to compile them.
- The OECD (2016) provides an overview of the many national efforts to compile similar accounts, including by Canada ("maritime sector"), Portugal ("sea satellite account"), and the US ("ocean economy satellite account"). Over two dozen countries and international organisations are at various stages in the creation of formal or informal versions of their national income accounts and related statistical systems to monitor the relationship of economic activity to the ocean.
- The intent of all these approaches is to demonstrate the importance of the ocean to the national and regional economies, to track ocean sectoral policies and to better understand the cross impacts with non-ocean policies. For example, development policies to increase construction of inland infrastructure may lead to coastal flooding and dispersion of pollutants into coastal areas. This could risk lowering production in inshore fisheries. Conversely, clearing mangroves for aquaculture, while increasing aquaculture production, could decrease coastal protection and risk flooding or eroding coastal croplands and pastures.
- Since ocean economy satellite accounts are not defined in existing statistical standards, this section provides a typical structure as a starting point.

- **Table 13** below provides a basic example structure and measures of a potential ocean economy satellite account. The rows are characteristic ocean economy sectors, the columns represent the measures used to assess their performance. Performance can be measured in terms of Gross Value Added (GVA), Gross Output (GO) and employment. All three can be stated in terms of direct, indirect (intermediate inputs) and induced impacts (final demand). Further guidance on these measures, data sources and compilation are provided in **Assessing the ocean economy**.
- "Direct" impacts, as described in **Scope boundaries of Ocean Accounts**, are impacts (in terms of GVA, GO and employment) of "characteristic" activities that are most directly associated with the ocean. These can be occurring in the ocean (offshore oil and gas), be dependent on ocean products (oil refining) or be providing goods and services to activities on the ocean (manufacturing of components for oil rigs) (**Figure 6**).

Table 13. Example Ocean Economy Satellite Account (year)

Sector	**GVA (currency units constant)**				**Employment (thousands)**			
	Direct	Indirect	Induced	**Total**	Direct	Indirect	Induced	**Total**
Fishing/ aquaculture								
Offshore oil and gas								
Minerals								
Boat and ship building, maintenance and repair								
Marine renewable energy and distribution								
Marine construction								

Marine transportation & support activities								
Marine tourism & recreation								
Marine services								
Marine research and education								
Government								
ENGOs								
Total								
Growth from previous period (%)								
Whole economy (value)								
Whole economy (% in ocean economy)								

- "Indirect" refers to the inter-industry purchases (reflected in GVA, GO and employment) triggered by direct demand. For example, oil rig operators purchase food supplies from wholesale trade. Calculating the indirect impacts on wholesale trade requires the application of input-output analysis (I-O), which traces the transactions between sectors. Depending on the selection of "direct" industries, there may be double counting. For example, much of the output of the marine fishing sector goes to the fish processing sector. If these are both considered "direct", then their impacts will need to be adjusted to remove the value transferred between them.

- "Induced" impacts are the amounts (in terms of GVA, GO and employment) generated by employees (in direct and indirect activities) spending their wages and incomes. For example, an employee of a fish processing (direct) company purchases a car (induced). The implications of this spending on the GVA, GO and employment of the automobile industry can also be calculated using I-O.
- Varying definitions for ocean satellite accounting exist nationally. In the United States of America Ocean Economy Satellite Account, "intermediate inputs" is a similar concept to "indirect". However, "final demand" is broader than "induced" since it also includes induced spending by business and government, in addition to exports. An internationally applicable standard is an area of research for this framework.
- Linking ocean economy satellite accounts more precisely to the overall SEEA concept of natural inputs and ecosystem services requires further conceptual development. Testing is required to reconcile the "activity" perspective of ocean economy satellite accounts with the "service" perspective of the flows of natural inputs and ecosystem services. This will be included in the future research agenda.

2.6.1 Defining and classifying the ocean economy

- The SNA 2008 conceptually includes all marine and ocean-related economic production including subsistence, informal and illegal activities. The International Standard Industrial Classification of All Economic Activities (ISIC Rev. 4) includes categories for marine fishing (0311), marine aquaculture (0321), sea and coastal water transport (501), and other ocean-specific industries. The definition of ocean related activity is continually evolving and may differ considerably by nation region, or industry. For example, there are differences between ocean-related ISIC codes (**Table 14**) and those used by ocean-related industry at the national level (for example: Australian and New Zealand Standard Industrial Classification codes). The definition should be measurable using a variety of economic statistics, including output, employment, wages, number of establishments, etc. consistent with national statistical series.
- **Table 14** combines ISIC codes identified by Wang (2016) and those listed by Colgan (2018) as being specifically included in ISIC Rev. 4 or referenced in national and international ocean economy reports and plans. **Appendix 6.6** provides further examples and the derivation of **Table 14**.

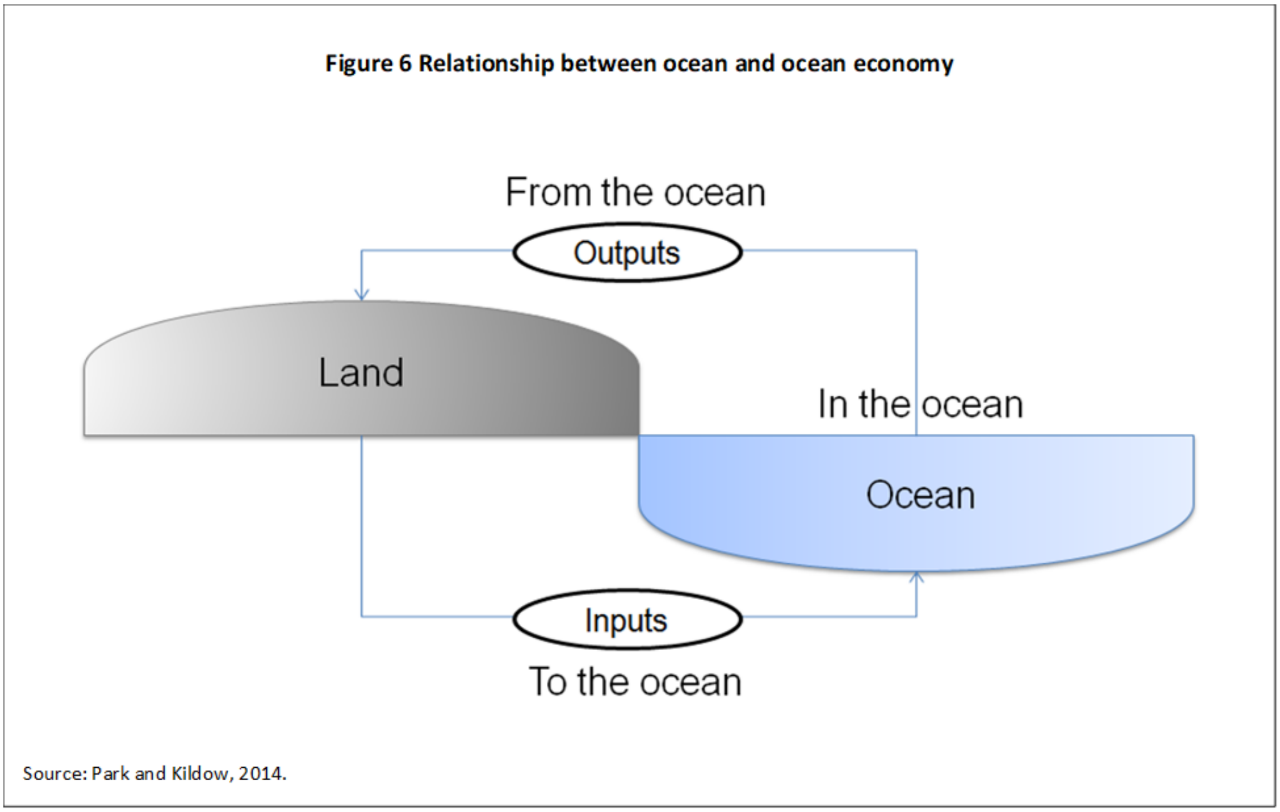


Figure 6. Relationship between ocean and ocean economy. Source: Park and Kildow, 2014

Table 14. Ocean-related ISIC codes

Sector	ISIC Code	Description	Ocean share
Ocean-related hunting and trapping (walrus, seals)	0170	Hunting, trapping and related service activities	Partial
Fishing/aquaculture	0311	Marine fishing	Full
	0321	Marine aquaculture	Full
Offshore oil and gas	0610	Extraction of crude petroleum	Partial
	0620	Extraction of natural gas	Partial
Marine mining and quarrying	0810	Quarrying of stone, sand and clay	Partial

	0890	Mining and quarrying n.e.c.	Partial
	0893	Extraction of salt	Full
Mining support service activities	0910	Support activities for petroleum and natural gas extraction	Partial
	0990	Support activities for other mining and quarrying	Partial
Marine manufacturing	1020	Processing and preserving of fish, crustaceans and molluscs	Full
	1394	Manufacture of cordage, rope, twine and netting	Partial
Marine chemical industry	2011	Manufacture of basic chemicals	Partial
	2029	Manufacture of other chemical products n.e.c.	Partial
	2100	Manufacture of pharmaceuticals, medicinal chemical and botanical products	Partial
Boat and Ship Building, Maintenance and Repair	3011	Building of ships and floating structures	Partial
	3012	Building of pleasure and sporting boats	Partial
Repair and installation of marine equipment	3315	Repair of transport equipment, except motor vehicles	Partial
Marine renewable energy and distribution	3510	Electric power generation, transmission and distribution	Partial

Salt water supply	3600	Water collection, treatment and supply	Partial
Waste management services	3700	~~Sewarge~~Sewerage	Partial
Marine construction	4290	Construction of other civil engineering projects	Partial
	4311	Demolition	Partial
	4312	Site preparation	Partial
	4321	Electrical installation	Partial
	4322	Plumbing, heat and air-conditioning installation	Partial
	4329	Other construction installation	Partial
	4390	Other specialized construction activities	Partial
Marine equipment wholesale	4659	Wholesale of other machinery and equipment	Partial
Marine equipment retail	4773	Other retail sale of new goods in specialized stores	Partial
Transport via marine pipeline	4930	Transport via pipeline	Partial
Marine transportation	5011	Sea and coastal passenger water transport	Full
	5012	Sea and coastal freight water transport	Full

Warehousing and support activities for transportation	5210	Warehousing and storage	Partial
	5222	Service activities incidental to water transportation	Partial
	5224	Cargo handling	Partial
	5229	Other transportation support activities	Partial
Marine tourism	5510	Short term accommodation activities	Partial
	5520	Camping grounds, recreational vehicle parks and trailer parks	Partial
	5590	Other accommodation	Partial
Food and beverage service activities	5610	Restaurants and mobile food service activities	Partial
	5621	Event catering	Partial
	5629	Other food service activities	Partial
	5630	Beverage serving activities	Partial
Marine information services	6311	Data processing, hosting and related activities	Partial
Marine insurance	6512	Non-life insurance	Partial
Marine geologic exploration	7110	Architectural and engineering activities and related technical consultancy	Partial

Marine research and education	7210	Research and experimental development on natural sciences and engineering	Partial
Marine/Environmental Consulting	7490	Other professional, scientific and technical activities n.e.c.	Partial
Travel agency, tour operator, reservation service and related activities	7911	Travel agency activities	Partial
	7912	Tour operator activities	Partial
	7990	Other reservation service and related activities	Partial
Ports (maintenance)	8130	Landscape care and maintenance service activities	Partial
Public adminstration and defence	8411	General public administration	Partial
	8422	Defence activities	Partial
Education	8521	General secondary education	Partial
	8522	Technical and vocational secondary education	Partial
	8530	Higher education	Partial
	8541	Sports and physical education	Partial
	8549	Other education n.e.c.	Partial
Libraries, archives, museums and other cultural activities	9102	Museums activities and operation of historical sites and buildings	Partial

	9103	Botanical and zoological gardens and nature reserves activities	Partial
Sports activities and amusement and recreation activities	9312	Activities of sports clubs	Partial
	9321	Other sports activities	Partial
	9329	Other amusement and recreation activities n.e.c.	Partial

Adapted from Wang (2016) and Colgan (2018). Full derivation and notes in **Appendix 6.6.**

- Many ocean-related sectors mentioned in national and international reports are not obvious and raise questions about how the relationship to the ocean is to be defined and measured, about the levels of aggregation in an ocean economy taxonomy, and about the relationships among industries in the ocean economy. Further research is required to develop an agreed definition and classification.

2.6.2 Reconciling activity and service approaches

- **Table 15** shows a high-level summary of the broader ocean economy. It is a summary of the "products" line in **Table 5** (**General Supply and Use**), that could be derived from compiling characteristic ocean commodities from existing monetary supply and use tables in the SNA.
- "Products and Services" supplied by industries could also be derived from the GVA of individual economic activities as described in the ocean economy satellite account. However, products and services are also imported, used in producing products, consumed by households and exported. The "use" section of this table shows the use in the economy including intermediate consumption (used to produce other goods and services), household final consumption (the energy we use and fish we eat), gross fixed capital formation (contribution to infrastructure and inventories) and exports.
- If data in **Table 14** and **Table 15** were complete and detailed, the totals would match. That is, the sum of the GVA of ocean commodities and the GVA of the sectors that produce them should be equal. However, data on both sectors and commodities are incomplete and one source may be used to inform the other. Further research is required to reconcile these two approaches.

Table 15. Ocean economy table: supply and use (monetary) (during accounting period)

	Industries	Households	Government	Accumulatio n	Rest of the World	Total
Supply table						
Products and services	Output				Imports	Total supply
Use table						

Products and services	Intermediate consumption	Household final consumption expenditure	Government final consumption expenditure	Gross capital formation (including changes in inventories)	Exports	Total use
	Value added					

2.7 Ocean governance accounts

2.7.1 Defining ocean governance for accounting purposes

- Ocean decision-making and decision implementation is shaped by, and embedded within, a complex web of relationships between individuals and institutions. The term "governance" is commonly used to refer to the many ways that individuals and institutions, public and private, manage their common affairs in this context. Governance of oceans is a process characterised by a wide variety of:
    - **Actors / institutions:** including governments, intergovernmental organisations (IGOs), private entities from commercial and non-profit sectors, and diverse communities within civil society.
    - **Norms:** including treaties, laws, regulations, policies, contractual agreements, technical standards.
    - **Behavioural relationships:** both actors and norms are influenced and shaped by relationships of authority, cooperation or influence at multiple levels. A particularly important behaviour for accounting purposes is the spending of money on ocean-related activities including but not limited to protection, management, and fiscal incentives.
    - **Spatial boundaries:** Different actors and norms operate at different spatial scales, including local, national, regional and international. A characteristic feature of oceans governance is the common misalignment of the spatial boundaries of governance at each of these scales, with the biophysical and spatial characteristics of the ocean environment. For example, many ecosystems and species straddle, migrate across, or are affected biophysically by activity located beyond jurisdictional boundaries (Milligan and O'Keeffe, 2019).
- These broad features of governance are an important subject of ocean accounting for several reasons, including the following:
    - Tracking how collective decisions are made about oceans is crucial to improving their effectiveness in the future.
    - Decision-making about oceans is commonly divided along sectoral lines (e.g. fisheries, transport, energy, telecommunications, tourism, environmental protection, etc.), reducing mutual awareness of ocean-related decision-making and relevant institutional responsibilities. One potential adverse consequence of low mutual awareness of decision-making is inter-sectoral spatial conflict arising from different authorities assigning competing rights to the same areas.
- Ocean governance accounts are an experimental component of the Ocean Accounts Framework that are currently being piloted and supported by targeted research. They incorporate specific elements of the SNA, SEEA–CF and SEEA–EEA but extend the scope of these frameworks to cover a wider range of phenomena.

2.7.2 Structure of governance accounts

- Ocean governance accounts can be structured into two broad categories of tables that record features and consequences of ocean-related decision-making from two complementary perspectives:
    - **Spatially explicit situation:** including the status for each relevant Spatial Unit of ocean zoning (jurisdictional and management zones), institutional responsibilities and rules for particular

activities, social circumstances (e.g. health, poverty, social inclusion), and circumstances relevant to the integrated risk and resilience profile of relevant environments, societies, and economies.
    - **Environmental Activity Accounts:** focusing on recording economic activity (e.g. government spending, taxes, subsidies) that is directly associated with management of oceans, based on the concepts and approaches documented in the Environmental Activity Accounts in the SEEA–CF (see See SEEA–CF Chapter 4, 6.2.4, 6.2.5).
- Illustrative tables for each of these two categories are presented in **Tables 16 and 17** below, which contain row entries for several proposed experimental components of ocean governance accounts. **Table 16,** recording the spatially explicit situation, can be integrated with other parts of the Ocean Accounts Framework that record economic or environmental conditions within specific Spatial Units. Some components of the Table will be more or less relevant depending on the spatial focus of the relevant account —for example indicators of certain social circumstances may not be relevant accounting subjects except for coastal Spatial Units.

Table 16. Governance table: spatially explicit situation (at end of accounting period)

Repeat as needed for each Depth Layer:	Spatial Unit 1	Spatial Unit 2	Spatial Unit 3	*Measurement Units*
Zoning				
Jurisdictional zone (e.g. Internal Waters, Territorial Sea, EEZ/CS)				*Type classification based on national laws and policies*
Management or planning zone (e.g. protected area, private property, aquaculture, energy development, submarine cable corridor, locally managed marine area, etc)				*Type classification based on national laws and policies* *Written comments and references to official sources*
Rules and decision-making institutions				
Activity 1 (e.g. small-scale fishing)				*Written comments and references to official sources*

Activity 2 (e.g. industrial fishing)				*Written comments and references to official sources*
Activity 3 (e.g. wind farm development)				*Written comments and references to official sources*
Social circumstances				
Topic 1 (e.g. Public health)				*Appropriate indicators*
Topic 2 (e.g. Poverty)				*Appropriate indicators*
Topic 3 (e.g. Social inclusion)				*Appropriate indicators*
Risk and resilience				
Topic 1 (e.g. Flood / storm surge risk)				*Appropriate indicators*
Topic 2 (e.g. Resilience)				*Appropriate indicators*

Note: The spatial detail in this table is more feasible and essential for indicators related to zoning and institutions. Indicators of social circumstances and risk and resilience are still under discussion.

- **Table 16** is designed to flexibly accommodate a wide range of qualitative and quantitative information sourced from other indicator and classification frameworks, including but not limited to:
  - The 2013 Framework for Development of Environment Statistics, in particular Component 6 focusing on environmental protection, management and engagement.
  - The IUCN Protected Area Categories, which classify protected areas according to their management objectives, and are used by many national governments as the global standard for defining and recording protected areas. The IUCN has also published supplemental guidelines for applying the Protected Area Categories to Marine Protected Areas.
  - Spatially disaggregated information aligned with the 38 indicators identified under the Sendai Framework for Disaster Risk Reduction, which are used as a basis for measuring progress towards the global targets recognized in the Sendai Framework.
  - Spatially disaggregated information aligned with the dimensions of poverty recognised in the UNDO Multidimensional Poverty Index.
  - Spatially disaggregated information aligned with the WHO Global Reference List of 100 Core Health Indicators.
  - The FAO Resilience Index Measurement and Analysis framework which quantitatively examines the ability of households to cope with shocks and stressors.

- **Table 17,** recording environmental economic activity per sector features a combined presentation of specific components of the SEEA that focus on protection and management expenditure, environmental goods and services, taxes and subsidies, etc. — for more information refer to SEEA–CF Section 4.3. Depending on availability of spatial detail, these could be compiled by spatial unit and incorporated into **Table 16**. This would show, for example, total environmental protection expenditures in a given spatial unit.

Table 17. Governance table: environmental economic activity per sector (at end of accounting period)

	Industry 1 (e.g. shipping)	Industry 2 (e.g. fisheries)	Industry 3	Government
Environmental protection expenditure				
Of which R&D expenditure				
Value of environmental goods and services provided				
Environmental taxes less subsidies				

2.7.3 Specific experimental components of governance accounting

- Illustrative proposed methods and approaches for compiling these can be summarised as follows:
- ***Ocean zoning:*** Accounting for ocean zoning can be achieved by assigning consistent type classifications to Spatial Units. These provide a qualitative description of how the area within a given Spatial Unit can be distinguished from others in accordance with relevant laws, regulations and policies, for the purposes of government decision-making. Two general classification categories for ocean zoning are proposed, which are based on how ocean space is commonly classified by international agreements, and relevant national laws and policies:
- **Jurisdictional zone**: international agreements, in particular the 1982 United Nations Convention on the Law of the Sea, recognise a series of maritime zones in which countries are attributed certain rights and obligations, either as the relevant "coastal state" (which claims the zone or is automatically entitled to it), "flag state" (in relation to its registered vessels) or "port state" (in relation to vessels located in port). These zones are classified in the 1982 Convention and related agreements as follows:
    - *Internal waters:* located landward of a "territorial sea baseline" designated by the coastal state and treated as equivalent to land territory being subject to the permanent sovereignty of that state. Ports are treated as internal waters.
    - *Territorial sea:* extending up to 12 nautical miles seaward from the designated baseline, subject to the sovereignty of the coastal state, with specific rights of "innocent passage" afforded to foreign vessels.

    - *Archipelagic waters:* located between islands of an archipelagic state (e.g. Indonesia, Jamaica, Fiji, Seychelles) enclosed by an “archipelagic baseline”, subject to the sovereignty of that state, with specific rights of passage afforded to foreign vessels.
    - *Exclusive economic zone:* extending up to 200 nautical miles seaward from baseline, in which the coastal state enjoys certain “sovereign rights” related broadly to the management of ocean resources (e.g. fisheries, energy). Subject to these rights, foreign vessels enjoy “freedom of navigation”.
    - *Continental shelf:* extending 200 miles seaward from baseline, or further in certain defined cases, in which the coastal state enjoys certain sovereign rights (e.g. related to oil and gas) and the flag state enjoys certain navigational freedoms (e.g. to lay cables and pipelines). The continental shelf and EEZ both cover the seabed and subsoil, with only the latter zone covering the water column and superjacent airspace.
    - *High seas:* located beyond national jurisdiction, in which countries enjoy broad non-exclusive rights (e.g. freedom of fishing) unless they agree otherwise.
    - *Deep seabed:* located beyond national jurisdiction, treated by the 1982 Convention and related agreements as being the “common heritage of mankind”, and subject to an international management framework (focused predominantly in practice on regulation of seabed mining).
- The suggested approach to account for these zones, which are illustrated in **Figure 7** below, it to record the zone designation(s) present within each Spatial Unit, alongside a reference to the associated enabling law or policy, e.g.: “*Continental Shelf: Continental Shelf Act 1972”*.
- In addition to the jurisdictional zone classifications listed above, a Spatial Unit could be recorded as an *Overlapping Claim Area* where multiple countries assert maritime zones that have not yet been delimited by an agreed maritime boundary.
- **Management or planning zone**: supplementing the general jurisdictional zone designations listed above, coastal states also designate a wide variety of specialised zones under national laws and policies for the purposes of ocean management, regulation or planning. These include, but are by no means limited to: *Fisheries zones, renewable energy zones, gas storage zones, protected areas, aggregate extraction zones, shipping lanes, etc.* The suggested approach to account for these zones is to record the relevant classification(s) for each Spatial Unit, alongside a reference to the associated law or policy, e.g.: “*Gas importation and storage zone: Energy Act 2008”*.

Figure 7. Basic jurisdictional framework for ocean governance

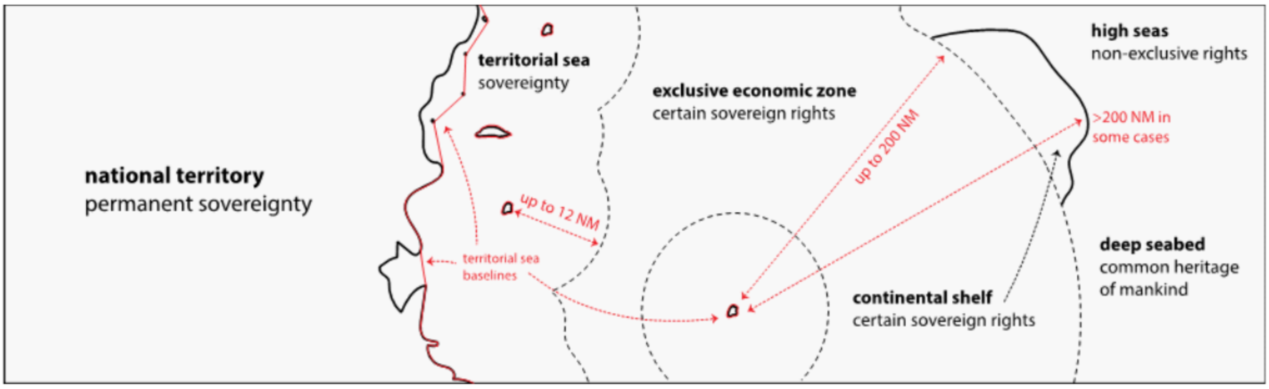


Figure 7. Basic jurisdictional framework for ocean governance. Note: diagram excludes archipelagic waters.

- ***Rules and decision-making institutions:*** In most countries, management, regulation and planning of ocean space falls under the authority of multiple institutions, each of whom is responsible for applying specific laws, policies, regulations, and other formal or informal norms. These characteristics of ocean governance can be accounted for with succinct qualitative descriptors, similar to those suggested above for ocean zoning.

- In **Table 16** these descriptors are assigned functionally — i.e. each table entry describes the institution(s) responsible for certain decision-making about a specific activity, alongside the norms considered relevant to that activity. For example, the following entries (**Table 18)** could be recorded for the relevant Spatial Units, providing a multi-functional summary of key governance conditions within each Unit.
- To maintain consistency within the accounts, clear entry and review protocols and illustrative sample language could be developed, including where appropriate general disclaimers that the account entries should not be relied on as definitive statements of the content of relevant laws, regulations or institutional mandates.

Table 18. Governance table: illustrative summaries of rules and decision-making institutions (at end of accounting period)

	Spatial Unit 1	Spatial Unit 2
Rules and decision-making institutions		
Activity 1 (small-scale fishing)	Small-scale fishing (vessels <5m) subject to licence and quotas, approved by community management committee in accordance Coastal Fishing Regulation 1973, section 53. See [insert cross-reference to full text of relevant law/policy/regulation or other primary source]	Small-scale fishing (vessels <5m) does not require approval provided landed tonnage <X in accordance with Coastal Fishing Regulation 1973, section 52. See [insert cross-reference to full text of relevant law/policy/regulation or other primary source]
Activity 2 (sand extraction)	Prohibited in accordance with Environment Ministry order 27, under Protected Areas Management Act 1996, section 52. See [insert cross-reference to full text of relevant law/policy/ regulation or other primary source]	Requires licence issued by the Environment Ministry in accordance with the Mining Act 2004, section 14. See [insert cross-reference to full text of relevant law/policy/regulation or other primary source]

- ***Protection and management:*** The scope of these monetary flows is expenditures whose primary purpose is: *(1)* the prevention, reduction and elimination of pollution and other forms of degradation of the ocean environment; and *(2)* preserving and maintaining the stock of ocean assets and hence safeguarding against depletion. Accounting for protection and management expenditure in the Ocean Accounts Framework follows the same approach as the SEEA-CF Environmental Activity Accounts — refer to Table 4.4 of the SEEA–CF.
- ***Environmental goods and services:*** The scope of these monetary flows includes the production of a specified range of environmental goods and services, including environmental protection and resource management specific services, environmental sole-purpose products, and adapted goods. Accounting for environmental goods and services in the Ocean Accounts Framework follows the same approach as the SEEA–CF Environmental Activity Accounts — refer to Table 4.6 of the SEEA-CF
- ***Taxes and subsidies:*** Environmental taxes are those whose tax base is a physical unit (or a proxy of it) of something that has a proven, specific negative impact on the environment. Environmental subsidies and similar transfers are those intended to support activities that protect the environment or reduce the use and

extraction of natural resources. Subsidies generally are current unrequited payments that government units, including non-resident government units, make to enterprises on the basis of the levels of their production activities or the quantities or values of the goods or services that they produce, sell or import.

- These fiscal flows are a relevant subject of ocean governance accounts because they can have a profound influence on decision-making concerning oceans—for example, the effort level of fishing activities. Accounting for taxes and subsidies in the ocean accounts framework follows the same approach as the SEEA–CF Sequence of Economic Accounts — refer to Table 6.3 of the SEEA–CF output and uptake metrics.
- ***Social circumstances:*** There is broad recognition that there are strong links between poverty and the environment, often referred to as the poverty-environment-nexus (PEN). These links are prevalent in many marine and coastal contexts given the exposure of coastal communities around the world to natural hazards and disasters, and to food and livelihood insecurity linked to the widespread decline of marine ecosystems.
- The Poverty Environment Accounting Framework (PEAF) provides a basis for organising health, poverty and social inclusion statistics into tables that are interoperable with other components of Ocean Accounts. PEAF is an application of the accounting principles described in SEEA that can be used to underpin a range of PEN indicators falling within the scope of the **Combined Presentation Table Group**.
- This experimental component of the ocean accounts framework will be prototyped using a social accounting matrix approach in alignment with Chapter 28 of the SNA 2008 with the focus on ecosystem assets and condition, services, benefits, and beneficiaries and their linkages to key socioeconomic statistics such as income, employment, health disaggregated by ocean-related target populations.

Risk and resilience

- Resilience is commonly defined as the ability of households, communities and nations to absorb and recover from shocks, whilst positively adapting and transforming their structures and means for living in the face of long-term stresses, change and uncertainty. A related concept of "ecological resilience" is commonly defined as the amount of disturbance that an ecosystem could withstand without changing self-organized processes and structures, defined as alternative stable states. A broader concept of "socio-ecological resilience" is commonly defined as the capacity to adapt or transform in the face of change in social-ecological systems, particularly unexpected change, in ways that continue to support human well-being. Regular time series of spatially explicit indicators of these phenomena can provide useful guidance to decision-makers tasked with weighing and responding to risks.
- ***Technologies:*** Investments in ocean research and technologies has led to rapid development over the past decades. Some examples include the use of advanced technologies in the fisheries and aquaculture sector, research and development on marine technology and biotechnology, as well as enhancement of early warning systems for resilience building in coastal cities. Accounting for investment in ocean-related research and technology development activities follows the general approach to functional accounts discussed in the SEEA-CF.

2.8 Combined presentation (summary tables)

- The objective of the combined presentation is to summarize, aggregate and combine the main information — physical, monetary and/or qualitative data —derived from component tables and accounts within the ocean accounts framework as well as from other accounts regarding the annual production and expenditures on ocean-related activities (see SEEA-CF, p. 253, Section 6.4).
- Including ecosystem-related information in combined presentations is a relatively new idea, so this section is intended to fuel discussion, such as the use of different 3D levels, rather than present standard approaches.

2.8.1 Defining the combined presentation

- The combined presentation organizes and records key ocean-related aggregates and indicators that illustrate interactions (i.e., benefits and costs) between the ocean and the economy into a single information "dashboard" or "report card" for decision making. The scope and structure of the combined presentations is subject to policy questions, analytical interest and data availability which may be varied depending on different local contexts. Knowledge and experiences from national pilot testing and experimentation of the ocean accounts framework could be used to derive and provide examples of report cards and their use cases in support of national ocean policies and strategies. The continued development of combined presentation is a key area of future work of this technical guidance.

- Generally, the information to be included in the benefits and costs accounts is a summary of the annual monetary and physical supply and use of ocean products and ocean non-market services, the gross value added (GVA or contribution to GDP less taxes plus subsidies on products) of the market benefits, employment in ocean-related industries, expenditures to manage the ocean, and related taxes and subsidies.
- The accounts could be detailed by relevant industries, ecosystem types, ocean products (including ecosystem services), and beneficiary types (e.g., low/high income, small-scale/large-scale fishers, coastal/inland households).

2.8.2 Components of the combined presentation

- In the SEEA-CF, combined presentations are suggested for physical and monetary flows for energy, water, forest products, and air emissions. All four tables follow the same structure of:
    - Relevant economic units – *i.e.* industries, households, government, accumulation, flows with the rest of the world
    - Monetary supply and use flows (including supply of products, intermediate consumption and final use, gross value added, depletion-adjusted value added, environmental taxes and subsidies and similar transfers)
    - Physical supply and use flows including Supply of natural inputs, products of residuals; Use of natural inputs, products and residuals
    - Asset stocks and flows (including opening and closing stocks in physical and monetary terms, depletion in monetary terms, and gross fixed capital formation (investment)
    - Related socio-demographic data such as employment and population
- The SEEA-CF combined presentation tables then focus on details particular to the topic, such as types of energy products, forest products or air emissions.
- The Ocean Accounts Framework provides a basis for recording many of these accounts in a spatially detailed manner, and possibly in three dimensions. This will benefit the understanding of where the assets are, from where they flow into the economy, and where their conditions are good or poor. See **Table 19** for an initial summary of the types of information that could be included.

2.8.3 Ocean GVA and GDP

- The SEEA-CF (p242, Section 6.2.4) follows the SNA approach to establishing the sequence of economic accounts. This section provides guidance on including environmentally related transactions and flows in the production account, generation of income account, allocation of primary income account, distribution of secondary income account, use of disposable income account, and the capital account. Depletion adjustment can be done for each of these accounts.
- SEEA Ecosystems Technical Recommendations provides an overview of a simplified sequence of accounts (SEEA-CF, Table 8.2, p. 135). This offers two models to treat the concept of ecosystem services and related gross value added and degradation adjusted net saving. In one model, ecosystems are treated as distinct producing unite. The recommended approach, however, is to allocate the degradation of ecosystem assets to the institutional sector that owns it.
- Given the calculation of gross value added in the ocean economy satellite account, the contribution of the ocean to GDP is the GVA for all institutional sectors plus taxes less subsidies on products.

2.8.4 Depletion, degradation, adjusted net savings

- In the SEEA-CF, degradation and depletion are treated much as depreciation of fixed assets in the SNA:
    - **Degradation** considers changes in the capacity of environmental assets to deliver a broad range of ecosystem services and the extent to which this capacity may be reduced through the action of economic units, including households. (SEEA-CF para. 5.90)
    - **Depletion**, in physical terms, is the decrease in the quantity of the stock of a natural resource over an accounting period that is due to the extraction of the natural resource by economic units occurring at a level greater than that of regeneration. (SEEA-CF para.5.76)
- The discussions on the SEEA EEA Revision (Discussion Paper 5.4) adapt this as a basis for conceptualizing ecosystem degradation. To facilitate this, physical changes in ecosystem condition are separated from the decrease in expected ecosystem services flows:
    - Ecosystem **deterioration** is the reduction in ecosystem condition due to human activity;
    - Ecosystem **degradation** is the decrease in ecosystem services flows due to ecosystem deterioration; and
    - Ecosystem **enhancement** is the increase in ecosystem services flows due to the increase in ecosystem condition due to human activity (e.g., restoration).
- Discussion Paper 5.4 also points out some additional considerations:
    - The multiple services arising from changes in one ecosystem asset may be complementary or competing. Therefore, a change in condition may result in decreases some services and increases in others.
    - Multiple services may have different beneficiaries, affecting different economic units in different ways.
    - Changes in condition maybe due to the actions of multiple economic units (such as climate change). This could be reflected in the condition accounts as "unmanaged regression".
- Given the possible combinations of changes in ecosystem assets, **Table 18A** indicates how these are to be allocated in a monetary asset table:

Table 18A. Recording changes in ecosystem assets in monetary ecosystem asset table (adapted from Table 2 in DP5.4)

Change type	Reason for change	Increase in expected ecosystem services flows	Decrease in expected ecosystem services flows
Reduction (decline) in ecosystem condition	Due to human activity (deterioration)	Other changes in volume	Degradation
	Due to natural influences	Other changes in volume	Catastrophic loss, (disappearance)
Increase (improvement) in ecosystem condition	Due to human activity	Enhancement	Other changes in volume
	Due to natural influences	Appearance	Other changes in volume
No change in ecosystem condition		Other changes in volume	Other changes in volume

- Decomposing changes in aggregate service flows into changes in volume (i.e., area of the asset) and changes in flows of individual ecosystem services (whether increasing or decreasing) given multiple conditions can be done between two periods of time (see Discussion Paper 5.4).
- The component of changes in aggregate service flows due to changes in ecosystem condition can be used in the calculation of degradation adjusted net savings as illustrated in the SEEA EEA Technical Recommendations (Table 8.2).

2.8.5 Non-SNA contributions to well-being

- As noted in **Flows to the economy**, non-SNA benefits of the ocean need to be accounted for but cannot be comprehensively represented in monetary terms. For this reason, it is recommended that that measurement of non-SNA benefits focus on physical measures. A combined presentation for the ocean could include physical flows of regulating and maintenance services (e.g., tonnes of carbon sequestration, hectares of habitat, metres of coastal protection) together with summaries of cultural services and monetary values.
- Some of these services can be attributed monetary values, for example, it they are directly used with no required labour and capital or have an input to economic production. The cases of direct use are rather limited to gathering of wild products. These can be valued at the market equivalent value. In cases where ecosystem services contribute to economic production, such as captured fish, then the value attributed is the contribution of the fish to the market value. That is, the market value of the fish minus the cost of catching the fish.
- Some non-market services have been attributed social or global prices, such as the social cost of carbon. This, however, is not well-accepted for other non-market services. For example, marine plants produce oxygen, which has a market price. Since oxygen is not a limited resource, it would be misleading to put a monetary value on the oxygen produced.
- Yet other non-market services, such as habitats for iconic species and ecosystems that have sacred or religious meaning, should not be valued in monetary terms because of the implication of substitution. If a price, no matter how high, is attributed to these critical natural capitals (See **Environmental assets**), then we are assuming that, for a price, they can be converted to other uses. They could be represented in physical asset tables as critical natural capital in hectares or species, but not valued in monetary terms.
- Therefore, it is recommended that the combined presentation for Ocean Accounts distinguish between these four types of services: direct use, resource rent, physical quantities of regulating and maintenance services, and critical natural capital incorporating social values.

2.8.6 Health, poverty and social inclusion

- Opportunities for disaggregation to better understand the links between the ocean and social concerns require the disaggregation of beneficiaries of ocean-related services and populations at risk of ocean-related disasters. The System of National Accounts suggests a Social Accounting Matrix approach to link sub-populations (e.g., women, low-income, self-employed…) of concern with economic sectors. Ocean accounting can extend sub-populations of concern to include coastal communities, small-scale fishers seaweed farmers, mangrove harvesters, and local villagers.
- One aspect of being a beneficiary is employment in the industry. For example, the fisheries industry could (a) be aggregated by large and small-scale operations and (b) within those track employment of men/women, low-income/high-income, island/coastal/inland communities. Small scale operations and subsistence activities are often excluded in economic surveys used to compile national accounts.
- The other aspect of being a beneficiary is benefitting from non-market ecosystem services such as coastal protection and flood protection. These services could as well be disaggregated by sub-populations of concern. This could be represented in the services use account and summarized in the combined presentation as the quantity of those services used by these sub-populations relative to the size of the sub-populations. For example, at-risk poor coastal communities could represent 20% of the population yet receive only 10% of the coastal protection of mangroves due to their less favourable living conditions.
- Links between ocean services and health could be made in terms of nutrition received from the ocean and recreational benefits. The Millennium Ecosystem Assessment (MA 2005) called for “social analysis” of the

distribution of the benefits of ecosystem services (Daw, 2011). Such social analysis also includes broader inclusion of socio-ecological considerations such as co-production, power relations, institutions and governance, uncertainty and value pluralism (Solé & Ariza, 2019). In their literature review, Solé & Ariza (2019) conclude that "coastal ES studies fall short of considering the social components and social-ecological interactions of coastal systems". Therefore, establishing a comprehensive list of beneficiaries of ocean services, the services from which they benefit, and the extent of those benefits will continue to be a challenge. While there is literature on disaggregated beneficiaries of ocean services (Lange & Jiddawi, 2009, Hicks & Cinner, 2014, Hossein et al. 2017, ESPA n.d.), this will require targeted literature search and codification. Fisheries and Oceans Canada (2020) has initiated such a project and expects results by the end of 2020.

Table 19. Combined presentation (physical and monetary) (during accounting period)

At the current stage of development, **Table 19** is experimental and will require further research to develop approaches to allocating several of these indicators to specific industries.

Change type	**Reason for change**	**Increase in expected ecosystem services flows**	**Decrease in expected ecosystem services flows**
Reduction (decline) in ecosystem condition	Due to human activity (deterioration)	Other changes in volume	Degradation
	Due to natural influences	Other changes in volume	Catastrophic loss, (disappearance)
Increase (improvement) in ecosystem condition	Due to human activity	Enhancement	Other changes in volume
	Due to natural influences	Appearance	Other changes in volume
No change in ecosystem condition		Other changes in volume	Other changes in volume

2.9 Ocean wealth accounts

- This component of the Ocean Accounts Framework is dedicated to presenting summary information, in physical and monetary terms, concerning the status of a country's (or other region's) **stock of ocean wealth**. Wealth for the present purposes is broadly defined, to include all relevant:
    - stocks of environmental assets recorded on a SEEA balance sheet;
    - Economic/financial/produced assets recorded on an SNA balance sheet;
    - Societal assets (e.g. human or social capital) that are not yet recorded in internationally standardised formats within national accounting systems.
    - Status indicators for policy-relevant subsets of environmental wealth, including natural capital deemed "critical" according to nationally defined criteria, and discrete environmental assets that are amenable to measurement in terms of their resource life.
- **Tables 20 and 21** below provide illustrative examples of summary presentations of national ocean wealth that can be derived from more detailed balance sheets within the Ocean Accounts Framework. Illustrative Tables and approaches to account for societal assets are under development and will be incorporated into

future versions of this Guidance, informed by the OECD Human Capital indicators and generally related work.

2.9.1 Economic assets

- **Table 20** focuses on economic wealth, recording the status of relevant SNA assets in monetary terms at the end of an accounting period. The table is experimental in that future research would be required to allocate wealth of corporations, households and governments to the ocean.

2.9.2 Environmental assets

- **Table 21** focuses on environmental assets, recording the status of relevant SEEA assets in physical or monetary terms at the end of an accounting period. Additional columns could be added for stocks of ocean assets that are considered of particular importance — for example Ocean Assets designated as critical because of their irreplaceability, cultural importance, or other criteria (see below).

2.9.3 Critical natural capital

- Critical natural capital (CNC) refers to ecosystems, other environmental assets, species and processes that are ecologically, socially, or economically essential (Brand 2009; Rounsevell et al., 2010). Some definitions also include a criterion that the natural capital is "critical" because it is threatened (de Groot et al. 2003). CNC is not treated in the SEEA, although it is recognized that valuing natural assets in monetary terms is not a comprehensive assessment of their importance.
- A more precise definition would require assumptions about "critical to whom?", "over what time frame?", and "critical for what?". However, societies are well experienced in identifying some critical elements of nature that are so important to them that they set them aside from being substituted for other forms of capital. For example, most countries identify national parks and protect species. Many also consider some areas as "sacred" or of other cultural significance. In doing so, they are agreeing that this area or this species will not be sold or traded for any price.
- One possible representation in the Ocean Assets Environment Balance Sheet (Table 21) would be to include marine protected areas and cultural sites in terms of area, but not in monetary terms. Further, the number of protected coastal and marine species could be included. The table could be extended to show other areas or species of significance, as indicated in national policies, plans and strategies. This recognizes that all areas of ecological, economic, and cultural significance may not be formally designated as protected areas.

2.9.4 Resource life

- "Resource life" is the number of years any asset can be expected to provide a service. In national accounting, this is based on a rate of depreciation of capital assets. The resource life of natural assets is dependent on rates of depletion and degradation (see **Depletion, degradation, adjusted net savings**). This is a useful, if inexact, indicator that could be included in the Ocean Assets Environment Balance Sheet (Table 21).
- If a renewable asset is used sustainably, then its resource life could be infinite. However, the life of non-renewable assets is determined by the pattern of future exploitation. Fossil fuels, for example, are not renewed over the time scale of ocean accounting. Renewable assets, such as fish and seaweed, grow back after being harvested. However, this growth may be less than the amount harvested.
- To calculate the resource life of any asset, it is necessary to know the total stock of that asset, the rate of natural additions and removals if any, and the rate of managed additions and removals. This is described in **Environmental asset accounts.**
- The additional pieces of information required to calculate the resource life are the expected additions and removals into the future. The simplest approach would be to take the current net removals and divide by the current quantity if asset. For example, if an area of 500 ha of coral reef is being reduced (exploitation and

degradation minus regrowth and restoration) by 20 ha per year, one could estimate a resource life of 25 years.
- A less imprecise approach would be to establish an expected future scenario based on assumptions of patterns of exploitation and regrowth. For example, a national plan assuming an infinite life of fish stocks may not have taken into account that the future regrowth of fish stocks may be limited by pressures from exploitation and degradation.

2.9.5 Societal assets

- Societal assets (e.g. human or social capital) are not yet recorded in internationally standardised formats within national accounting systems. The OECD defines human capital as the "knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being". Societal assets, including human capital, are therefore interlinked with factors of economic growth and sustainability.
- The OECD provides guidance on methods to measure human capital, providing a distinction between indicator-based and monetary-based approaches. Indicators include a range of proxies such as adult literacy rates, school enrolment ratios, and average years of schooling. Monetary estimates involve direct, indirect, and residual approaches, related to official statistics produced from national accounts. The guidance advocates for the use of a range of indicators, noting the difficulty in aggregating statistics into an overall measure.
- The World Bank has produced a human capital index, which quantifies "the contribution of health and education to the productivity of the next generation of workers", linking indicators of health and education to the productivity of individuals and countries. Integrating measures of ocean-related societal assets is an area of development for this framework.

Table 20. National wealth table: Ocean Economy balance sheet (monetary)

	Corporations	Government	Households	**Total Economy**	Rest of the world	**Total**
Opening balance sheet						
Non-financial assets						
Financial assets / liabilities						
Total						
Total changes in assets						
Non-financial assets						

Financial assets / liabilities						
Total						
Closing balance sheet						
Non-financial assets						
Financial assets / liabilities						
Total						

Table 21. National wealth table: Ocean Asset environment balance sheet (physical or monetary units) (at end of accounting period)

	Asset Type 1 (e.g. mangroves)	Asset Type 2 (e.g. seagrass)	Total / aggregate
Opening stock			
+ Additions to stock			
– Reductions in stock			
= Closing stock			
Measurement units	*Area / weight*	*Area / weight*	*Area / weight*
Opening condition			
Closing condition			
Measurement units	*Condition indicator (e.g. biodiversity, resource life)*	*Condition indicator*	*Condition indicator*

3. Process guidance for compilation of Ocean Accounts

Table of Contents

- This section, after reading the **Introduction**, is recommended as the starting point for multidisciplinary teams planning to engage in ocean accounting. All members of the team, data providers, compilers and users, should be familiar with the basic concepts and methods.
- This section provides guidance on planning for, managing, compiling and using Ocean Accounts. It draws from experience in SEEA[1] implementation and in Ocean Accounts pilots. This experience has proven that developing reliable, quality and relevant statistics benefits from stakeholder engagement throughout the process. If stakeholders agree on priorities and are well-informed about the concepts, they are more likely to contribute their expertise and to use the results.
- This section summarizes key components of the Ocean Accounts Framework. Included are the main recommendations on spatial data, asset extent and condition, services supply and use, assessing the ocean economy, governance and indicators.
- Ocean accounting builds on accepted international statistical frameworks to harmonize environmental, social and economic data about the ocean. By "ocean", it refers to coastal and marine areas, within and beyond national jurisdictions. "Accounting" refers to the standardization of data, including maps, so that data collected using different standards (concepts, classifications and methods) can be combined to tell a broader story—often the kind of story that is required to monitor progress towards policy objectives.
- The framework (**Figure 8**) is capable of organizing data in maps and tables on:
    - Pressures on the ocean (from SEEA-CF),
    - Ocean assets (extent and condition): ecosystems (from SEEA-EEA) and individual environmental assets (from SEEA-CF),
    - Ocean services (supply and use): biotic and abiotic (combining SEEA-CF and SEEA-EEA), and
    - The ocean economy, including but not limited to "Ocean Economy Satellite Accounting" based on the SNA,
    - Governance: including how the ocean is managed, technologies used, and expenditures made to protect it.
- Some aspects of ocean assets and services can be valued in monetary terms and thereby contribute to measures of the ocean economy. However, not all values are monetary or could easily be expressed in

monetary terms. The ocean is an important contributor to climate stability, species diversity and cultural heritage. The Ocean Accounts Framework encompasses this broad sense of “values”.

> [1] System of Environmental Economic Accounting, a UN standard for integrating environmental and economic data. SEEA-CF is the “Central Framework” and SEEA-EEA is the current “Experimental Ecosystem Accounting” which is undergoing revision for 2020. See https://seea.un.org/.

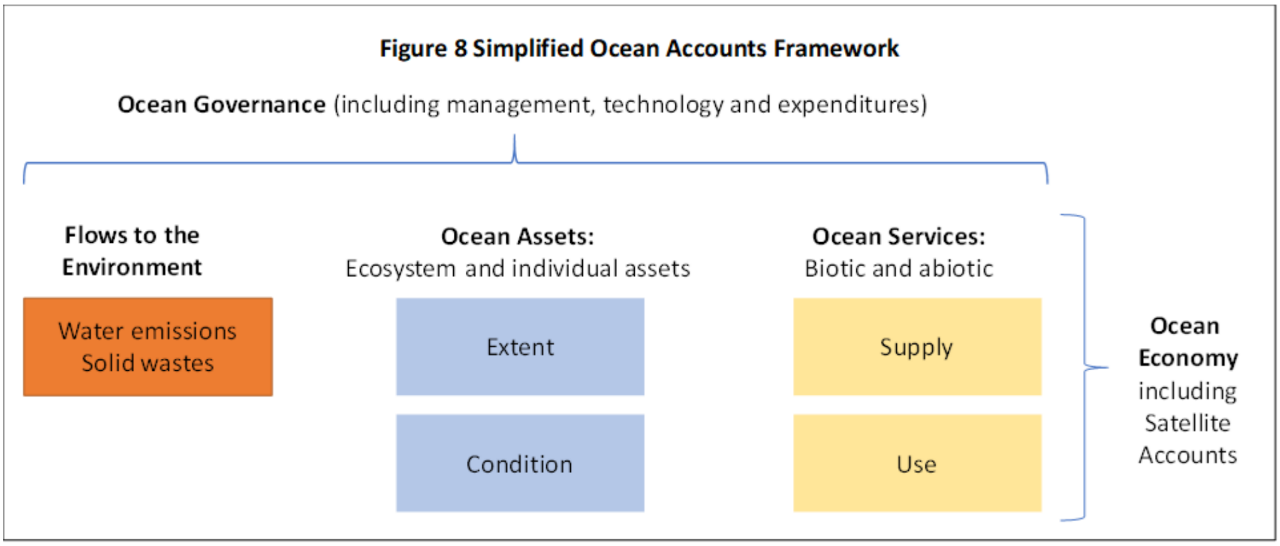


Figure 8. Simplified Ocean Accounts Framework.

3.1 Prioritisation and account development planning

- Creating a “complete” set of Ocean Accounts would be complex. However, experience in SEEA implementation has proven that (a) accounts don’t need to be complete and (b) to be policy relevant, not all accounts need to be developed. For example, countries have started SEEA water accounts with available data on municipal supplied water. This already proves the relevance of the accounts and attracts support for adding further detail.
- What has proven to be essential, though, is strategic planning in preparation for compiling accounts. The **Diagnostic Tool for Environment Statistics** is a means of guiding a structured conversation among stakeholders to determine which accounts and which parts of which accounts should and can be implemented first. In countries where there is no ongoing institutional mechanism for developing environment statistics, stakeholders consulted during the processes of applying the Diagnostic Tool could be considered the working group. This working group then contributes data, technical expertise and advice to the work as it progresses. Where there is an ongoing institutional mechanism, this could be the main means of engaging stakeholders.
- If this working group benefits from the guidance of a senior steering group, it is more likely that resources are made available and that the pilot results will be used to inform policy. The main components of the Diagnostic Tool are as shown in **Table 22**.

Table 22. Key actions for account development planning.

Diagnostic component	**Practical actions**

Statement of Strategy and Policy Priorities	• Document national visions and priorities related to the environment, biodiversity, sustainable development, and green economy, including managing natural assets and flows of services from them. • Link priorities to environmental concerns, such as pollution or overfishing.
Institutions	• Identify stakeholders including producers and users of related information (government agencies, academia, NGOs, international agencies), but also other groups such as civil society that can benefit from improved information • Identify relevant institutional mechanisms currently in place • Review the role of the National Statistical Office to highlight the advantages of integrating information and approaches across the National Statistical System.
Knowledge	• Identify key national data sources that can be used as a basis for further development.
Progress	• Understand what progress has already been made in developing environment statistics and accounts.
Context	• Identify related statistical development activities that could benefit (and benefit from) environment statistics initiatives.
Priorities	• Determine the priorities for action to develop selected environment statistics.
Constraints and opportunities	• Assess (a) constraints to implementing specific environment statistics and (b) opportunities for immediate actions to address these constraints.

- The Diagnostic Tool has been designed for use in a workshop setting. However, iteration will be required to achieve consensus. For example, a small core group may draft initial responses and then present them to a larger group for discussion and revision.
- The approach applied in the ESCAP Ocean Accounts pilot studies has been to use the Diagnostic Tool outline as the structure of a more detailed scoping report. The scoping report may be coordinated by an independent consultant, the NSO or by a government agency responsible for the ocean. Some countries have found that engaging an independent consultant in producing the scoping report is more likely to reveal opportunities for improvement.
- The ESCAP pilots were all initiated by obtaining commitments from senior managers to proceed. Pilots have been initiated in other countries by government experts presenting initial results to policy experts as a demonstration of feasibility.
- Most pilot studies have identified data availability and access as major constraints. Even when data are known to be available, they may be distributed across many sources, use different standards and be difficult to access for confidentiality reasons. The general advice is to know what data you have by conducting an inventory of available data.[2] This may be initiated through the scoping process as a request to relevant data holders. Relevant data may also be available from global data sources (see **Data sources and platforms for Ocean Accounts**). Pilot studies have addressed these constraints in different ways:
    - using public data: may limit the scope of the study, and data may be difficult to quality check;
    - establishing data sharing arrangements with relevant institutions: may take time; and
    - conducting original field work and socio-economic surveys: takes time and resources.

ⓘ [2] See the ESCAP Environmental Data Inventory Template for guidance on possible metadata that could be collected.

- Most Ocean Accounts pilot studies have used the Scoping Report as input to a first national workshop. This workshop is an opportunity to review the scoping report, revise it if necessary and to agree on the focus of the pilot. It is also an opportunity for capacity building: to discuss related stakeholder activities and to conduct training[3].

ⓘ [3]Training materials are available on http://communities.unescap.org/environment-statistics.

- When discussing priorities, it is important to understand the broad scope of the Ocean Accounts Framework. Pilots to date have been designed to address topics and policy concerns shown in **Table 23** below.
- At a national level, addressing any one of the above priorities would be sufficiently challenging to justify a pilot study. However, choosing a smaller, sub-national study area could allow for addressing more than one topic. For example, more information may be available for a specific bay or coastline. Focussing on this as a study area would support a more comprehensive analysis, such as assessing all land-based sources of pollutants in the related terrestrial drainage area, mapping coastal and marine ecosystems and estimating the value of the ocean economy for that area.
- Stakeholders may be working with different definitions (e.g., coastal, ocean economy), concepts (values, condition, ecosystem services). Furthermore, some of the important concepts used by one stakeholder will be unknown to others. By presenting related work, stakeholders will better understand the concepts used.
- Once participants agree on priority topics, study areas and concepts, they are in a better position to contribute to planning the next stage of work. A work plan should specify roles and timelines to produce the final product. If the final product is chosen to address unresolved policy priorities, it would demonstrate the effectiveness of the framework and attract support for further work.

Table 23. Priority topics and policy concerns addressed in Ocean Accounts pilots

Topic	**Policy concern**
The value of the ocean economy, either broadly in terms of all ocean services (biotic and abiotic) or narrowly in terms of the contribution of non-market ecosystem services	Sustainability of ocean economy, equitable distribution of benefits, including sustainability of food supply (fish and aquatic plants)
Sustainability of ocean economy, equitable distribution of benefits	National climate change commitments (net carbon emissions), reducing biodiversity loss, improving disaster resilience,
To consolidate existing spatial information on ocean ecosystems extent and/or designated use as a precursor to conducting marine spatial planning (MSP)	Sustainable use of the ocean, reducing habitat degradation, reducing biodiversity loss, improving disaster resilience, establishing MPAs

Land-based sources of marine pollution including drainage-basin-level SEEA water, water emissions and solid waste accounts (especially plastics) linked to ecosystem condition	Reducing habitat degradation and biodiversity loss
Resource requirements (water, energy, land) of coastal tourism and/or the impacts of tourism (waste generation, land use, ecosystem impacts) on coastal ecosystems	Sustainability of tourism economy: providing sufficient resources and minimizing impacts on ecosystems (e.g., closures)

- When substantial progress had been made on the pilot ocean account, most pilot countries have held a second national workshop. This workshop is an opportunity to review preliminary results, to benefit from additional technical guidance and to develop the messaging for a release document. Such a document is important to (a) communicate the results of the compilation, (b) to link it to policy concerns, (c) and to solicit further input on improving the work. The steps for conducting pilot studies are summarized in **Figure 9**. The process was followed in all five ESCAP Ocean Accounts pilots, which demonstrated substantial results despite the short (6-month) time allocated.
- China's pilot focused on developing harmonised mangrove maps as well as improving the understanding of environmental assets of the mangrove ecosystems in Beihai Bay, one of China's important marine ecological sites. The results indicated that mangrove areas have expanded from 4.68 km^2 to 32.79 km^2 over 30 years due to restoration. Mangroves now have an estimated total carbon stock of 0.67 million tonnes.
- Malaysia examined food security risk (i.e., fish) along the Straits of Malacca under expected future climate variability. Preliminary results suggested that ocean primary productivity is more sensitive to climate change than to impacts from land, such as runoff of nutrients due to mangrove loss. Nevertheless, reduction in mangrove areas has an impact on landings of particularly sensitive fish species, such as anchovies.
- The pilot studies in Samoa, Thailand and Vietnam centred around sustainable tourism by linking tourism income, natural resources use, land-based pollution, and ecosystem impacts – but each country with a different starting point.
    - Samoa concentrated the pilot on developing for the first time the tourism satellite accounts (TSA) and linked with existing SEEA water and energy accounts. The results showed that in 2018 tourism directly contributed to 12.4% of GDP and 21.5% of employment, while using 11.5% of the water and 10.1% of the electricity.
    - Thailand, on the other hand, has well developed TSA but no prior SEEA compilations. Thus, the pilot selected the main tourist destinations in southern Thailand (Phuket, Krabi, Phang Nga, Trang, and Satun) as a case study which in total generated 16 billion USD in income in 2016. The study highlighted that although only one in nine persons in the five provinces were tourists, tourism used 21% of the water, 57% of the energy and was responsible for 26% of the waste and 28% of the greenhouse gas emissions. Thailand also started the mapping of tourism potential areas, risk areas and sites for conservation.
    - For VietNam, the pilot used Quang Ninh province as a case study to develop comprehensive ecosystem accounts with a focus on pollution and tourism. The study found an association between the reduction in mangroves, sea grasses and coral reefs and human-induced factors such as land conversion, aquaculture practices, land-based pollution from tourism and sea-based pollution. Viet Nam plans to extend its pilot to develop a marine spatial plan (MSP) for the province as a policy application using an ecosystem-based approach.
- These pilots provide practical examples that demonstrate how the Ocean Accounts Framework can guide the harmonization, standardization, and integration of ocean-related data to inform national policy priorities. They also contributed, through pilot knowledge and evidence, to the ongoing process of improving this Guidance.
- The remainder of this section provides guidance on compiling specific components of Ocean Accounts.

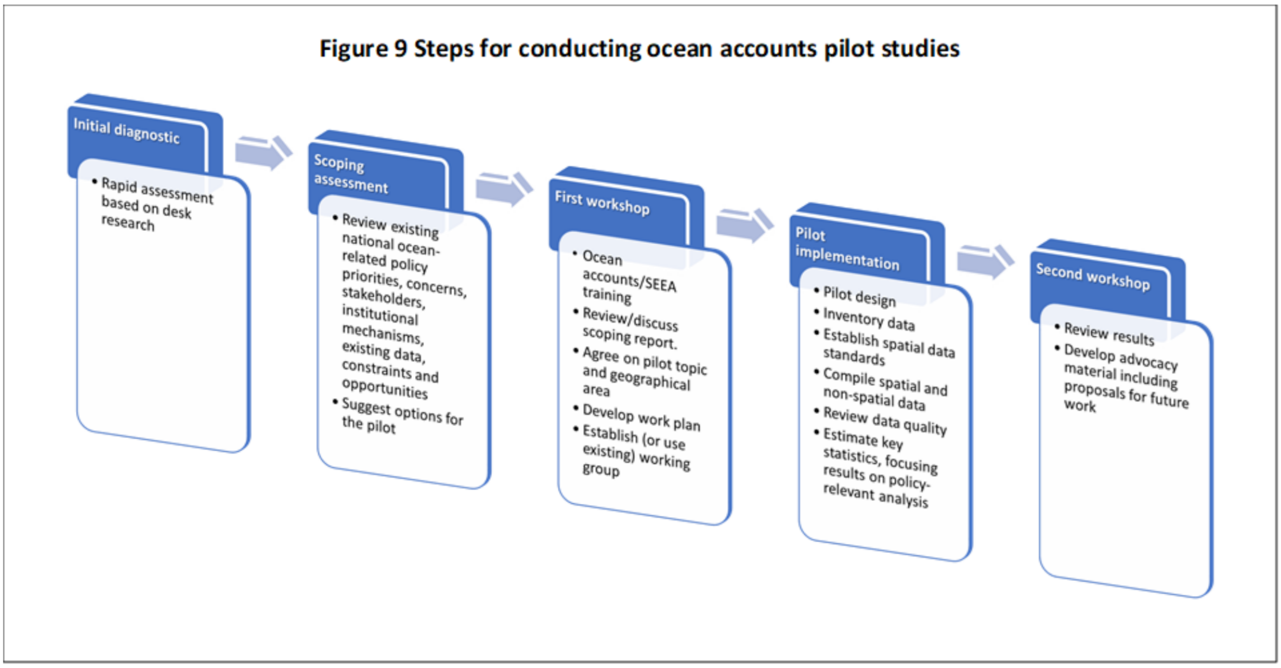


Figure 9. Steps for conducting ocean accounts pilot studies.

3.2 Developing a spatial database

- Ocean accounts can be built from maps (spatially explicit) or tables (spatially independent), but the power is in combining them. Maps can be used to generate tables and data in tables can be allocated to areas of the ocean.
- Establishing the spatial database for Ocean Accounts is an important early step that will facilitate the integration of spatial data from many sources. If the data sources already adhere to the standards of a National Spatial Data Infrastructure (NSDI) (See **The spatial data infrastructure for Ocean Accounts**) that includes coastal and marine areas (or Marine Spatial Data Infrastructure, MSDI), then spatial standards will not have to be developed specifically for the pilot. If not, then an ocean accounting pilot may be the catalyst to expand an existing NSDI to the country's EEZ.
- Many pilots have begun by compiling maps as a basis for a physical ocean asset extent account (see **Environmental asset accounts**). If there is no NSDI/MSDI, then standards such as shoreline vector, definition of "coastal", projections and scales will need to be established. It is possible to generate initial analytical results by overlaying spatial data in a GIS without creating an integrated spatial data infrastructure. However, this does not facilitate the production of the accounting tables. That is, to produce a physical Ocean Asset Extent Account (**Table 1)**, it is best to first align data (e.g., separate maps of mangroves, coral, seagrasses, etc.) using the same shoreline and spatial units. Doing this will ensure validation of the data by revealing gaps and overlaps.
- Although the Ocean Accounts Framework suggests spatial units (see **the spatial data infrastructure for Ocean Accounts**) and ecosystem classifications (see **Classification of ocean ecosystems**), pilot physical Ocean Asset Extent Accounts typically begin with existing national spatial units and ecosystem classifications.
- Including terrestrial and freshwater areas in the spatial database will facilitate the delineation of coastal and other transitional ecosystems. It will also facilitate the estimation of land-based sources of pollution to compile tables on land-based sources of pollutants (see **Flows to the environmental accounts (residuals)**, **Tables 10**, **11** **and** **12**).

> The Malaysia ESCAP Ocean Accounts pilot recommended distinguishing inshore from offshore areas for all accounts, regardless of ecosystem type. This would require agreement on the delineation of inshore and offshore. This could be set at the continental shelf or a specific depth. https://www.unescap.org/sites/default/files/1.3.A.2_Malaysia_GOAP_12-15Nov2019.pdf
> Canada is testing the use of 1 km hexagonal MBSUs. https://www.unescap.org/sites/default/files/2.2.A.1_Canada__Global_Ocean_Accounting_12-15Nov2019.pdf

- Estimating land-based sources of pollution can be done by (a) allocating national SEEA-CF Water Accounts, Water Emissions Accounts, and Solid Waste Accounts to drainage basin, or (b) in the absence of SEEA-CF accounts, aggregating industry and population by drainage basin and applying per-unit factors. Both require indicators on industry activity (e.g., employment in agriculture, mining, manufacturing) and population by drainage basin. These can be estimated by aggregating spatially detailed data from economic surveys and census of population to drainage basin. Similar techniques may be used to estimate coastal economic activity and population. See **Assessing pollutants (flows to the environment)** for further guidance.
- **Tables 10, 11 and 12** also include sources of pollutants by "marine area", which may be taken as an Ecosystem Accounting Area (EAA) as designated in national marine administration (for example, **Figure 10**). These should also be part of the spatial database.

3.2.1 Key data sources

- National agencies responsible for mapping and satellite imagery may have already established an NSDI (or "One map") that includes the ocean. However, information on bathymetry may be held by other agencies, such as fisheries or scientific research agencies. Relevant data may also be available from global sources. For example, the USGS/ESRI Global Shoreline Vector and the General Bathymetric Chart of the Oceans (GEBCO) are both recommended for testing.

3.2.2 Components of a spatial database

- Basic elements of the spatial data infrastructure include shoreline, bathymetry and the designation of spatial units (i.e., MBSUs based on a grid or other spatial framework), definition of "coastal", map projection and scale. These then are used to create an initial spatial database (in a GIS) upon which other data are overlaid or estimated.

Figure 10 Example of overlaying drainage basins with marine admini strative areas (Malaysia)

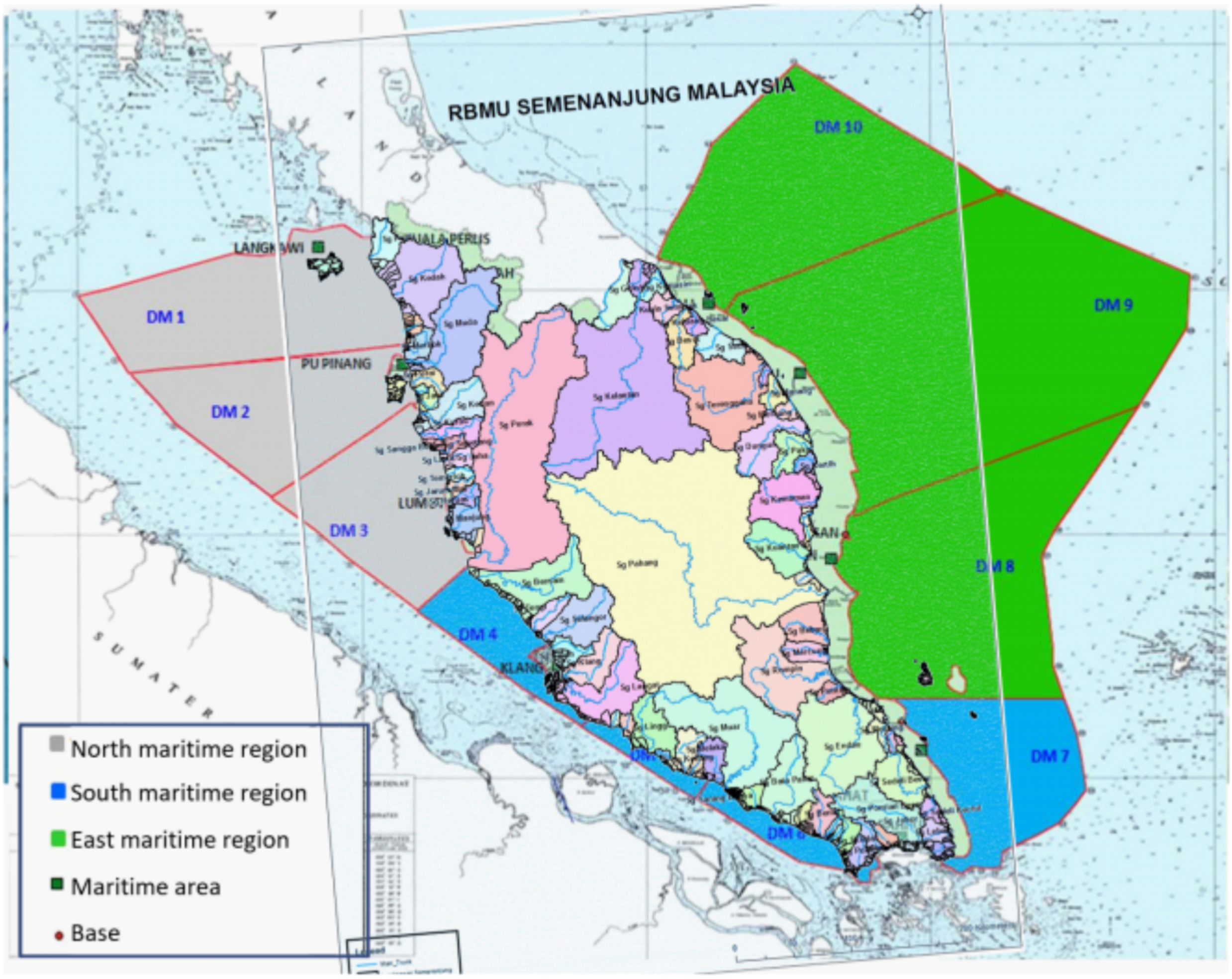


Figure 10. Example of overlaying drainage basins with marine administrative areas (Malaysia). Note: This is a simple overlay of two separate maps and has not yet been integrated into a single GIS database. Internal coloured areas are drainage basins.

- The geospatial database could also include climatic (ambient, hurricanes, tsunami, etc.), socio-economic (fish catch, mineral extraction, coastal population, shipping lanes, etc.) and other physical/bio datasets that will help address policy priorities expressed by stakeholders (e.g., risk from storm damage, impact of mineral extraction, sustainability of fish catch). Some of these datasets would be beneficial in linking the framework to concerns of disaster risk and climate change. (See **Operational and management decisions**).
- In a comprehensive Ocean Account, all spatial data would be mapped at sufficiently high resolution to identify assets (including uses), conditions and services of concern. Land and ecosystem accounts are often based on 30 to 250m resolution. This level of detail may not be necessary for Ocean Accounts. Some pilots use a 1km grid, whereas global data may be on a 27km grid or larger.
- Having a plan for NSDI/MSDI development, institutional infrastructure and resources in place for update and maintenance will help ensure its longevity and sustainability. Integration of various spatial data sources would also highlight gaps and mismatches that would improve the usability of the source data.

> The Viet Nam ESCAP Ocean Accounts pilot integrated UNEP-WCMC's data on coral reefs and seagrasses with local data on mangroves, ports and protected areas (**Figure 11**) to assess changes in mangroves, coral and seagrasses with respect to port development, MPAs and shipping routes. https://www.unescap.org/sites/default/files/1.3.A.5_Viet%20Nam_GOAP_12-15Nov2019.pdf
> The Canada pilot has begun delineating bathymetry, salt marsh, eelgrass and kelp beds (**Figure 12**). https://www.unescap.org/sites/default/files/2.2.A.1_Canada__Global_Ocean_Accounting_12-15Nov2019.pdf

3.3 Assessing extent and condition of ocean assets

- Ocean assets encompass not only the living (biotic) components (mangroves, seagrasses, coral reefs), but also the non-living (abiotic) (beaches, rocky shores, minerals, energy), their landform (slope, depth), as well as their designated use (marine protected area, fishing area). Not many countries will have all this information available in spatial detail and in one spatial dataset. However, compiling what data are available nationally will support many analyses of policy interest, including marine spatial planning (MSP). For example, is the extent of mangroves declining? Where are the coral reefs that are at most risk from tourist impacts? Will allowing deep-sea mining impact any unique ecosystems?
- Furthermore, understanding the condition of those assets will support the assessment of their capacity to provide ocean services. Condition measures generally refer to quality measures (concentrations of BOD, plastics, pH and temperature), but also to broader measures such as species diversity, ecosystem diversity and "health" of fish stocks). It is highly recommended that measures of condition be compared to a reference condition. For example, BOD concentrations in the study area may be 15mg/l whereas in unpolluted seawater, they are less than 5mg/l. The condition indicator would show that current concentrations are three times higher than unpolluted water.
- Linked with the ecosystem extent maps, the assessment of condition will help identify degraded ecosystem assets that would benefit from rehabilitation and pristine ones that would benefit from protection. Compiling data on ocean asset extent and condition would contribute data to **Tables 1, 2** and **3**.
- As described in **Monetary Asset Accounts**, monetary values can be attributed to some assets by calculating the Net Present Value (NPV) of the future flows of services. This is discussed at length in Chapter V of the SEEA-CF and further guidance on compilation is not provided here. If developing Monetary Asset Accounts is to be attempted as part of a pilot study, it would require reliable measures of service values (See **Assessing supply and use of ocean services/inputs to the economy**) and agreed scenarios of future flows of those services.

3.3.1 Key data sources

- Initial ocean asset extent accounts will begin with national publicly available data and data that stakeholders agree to share. Ideally, this would begin with "official" and agreed (among stakeholders) data on locations of assets of interest and information on their condition. One or more departments (fisheries, environment, mining, energy, natural resources) responsible for aspects of the ocean may have spatial or tabular information that would benefit from consolidation into a "one map" for the ocean. (see **Developing a spatial database**).
- Initial scoping of ocean asset extent accounts should also consider relevant local studies conducted by regional or international organizations, NGOs or academic researchers. In the absence of local data, global spatial portals may provide a useful starting point (**Data sources and platforms for Ocean Accounts** and **Appendix 6.1**). However, global data sources should be used with caution for national analyses, since they may be based on generalizations, interpretations or estimates that may not coincide with local conditions.

Figure 11 Viet Nam pilot for Quang Ning province: subset of ocean assets (coral, seagrass, mangrove, protected areas, ports)

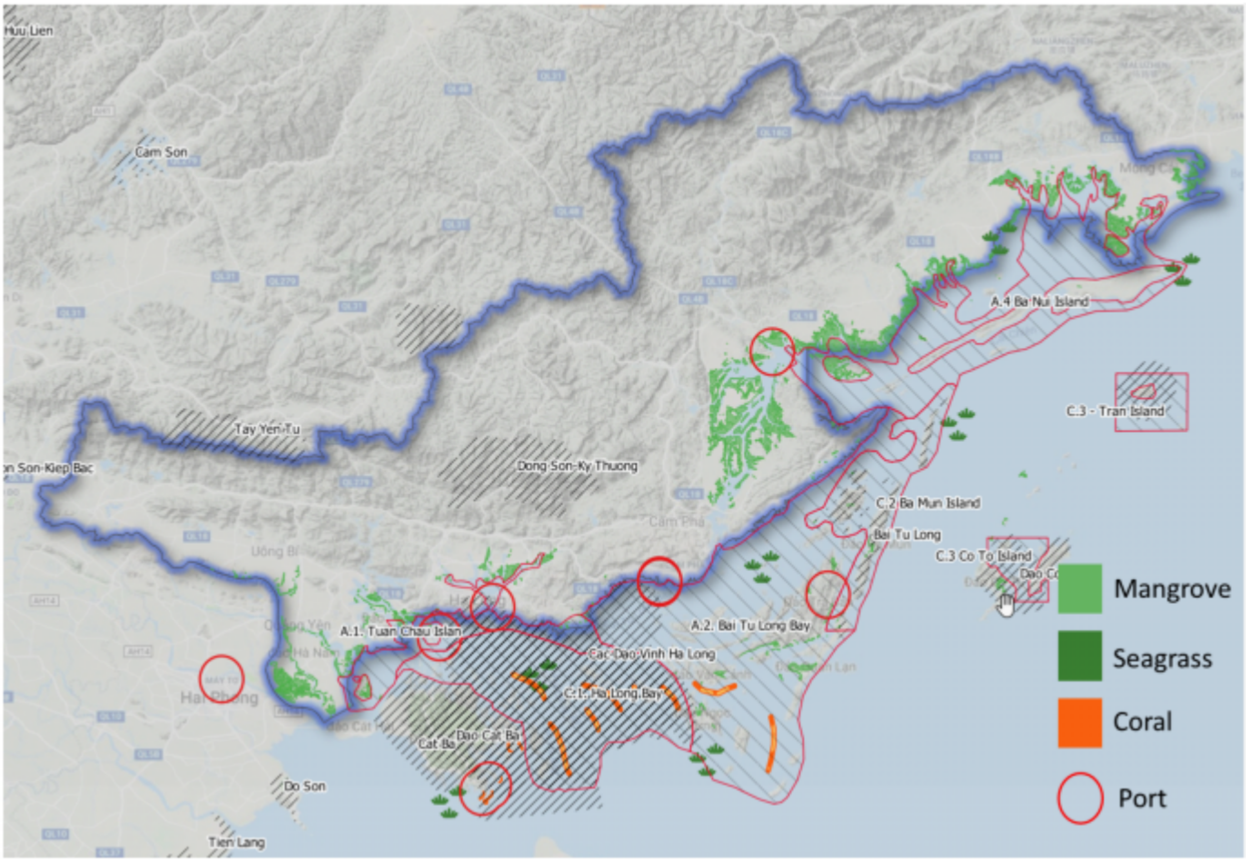


Figure 11. Vietnam pilot for Quang Ning province: subset of ocean assets (coral, seagrass, mangrove, protected areas, ports).

3.3.2 Ocean asset classification

- The Ocean Accounts Framework integrates ecosystems (SEEA-EEA) with “individual environmental assets” (SEEA-CF), recognizing that there are overlaps. The overlaps are more of a concern when monetary valuation is conducted, since the value of a seagrass bed would include the value of the commercial fish stocks living in it.
- Although this Guidance recommends the IUCN Global Ecosystem Typology (**Classification of ocean ecosystem services**, **Appendix 6.2**) as a reference classification for ecosystems., most countries will begin with existing ecosystem types that are of concern and have been studied. National classifications may already be in use and should be applied at initial stages of developing Ocean Accounts. The existing classification may not address all the requirements for comprehensive ocean accounting and, if so, could be further developed in future stages.
- Some key ecosystem types for which countries may have information include:
    - Coastal: beaches, coastal dunes, coastal flats, coastal water bodies (e.g., bays), estuaries, mangroves, rocky shores, saltmarshes, warm water coral,
    - Marine (to shelf): cold water coral, lagoons, seagrass beds (by type e.g., eelgrass), seaweed, warmwater coral reefs, pelagic (water column) and benthic (sea bottom).

- Marine (shelf to EEZ): softbottom/deepwater invertebrate communities (including heterotrophic coral), crustacean habitat, fish habitat, glass sponges, sea cucumber habitat, uninhabited sand, uninhabited rock, pelagic (water column) and benthic (sea bottom)

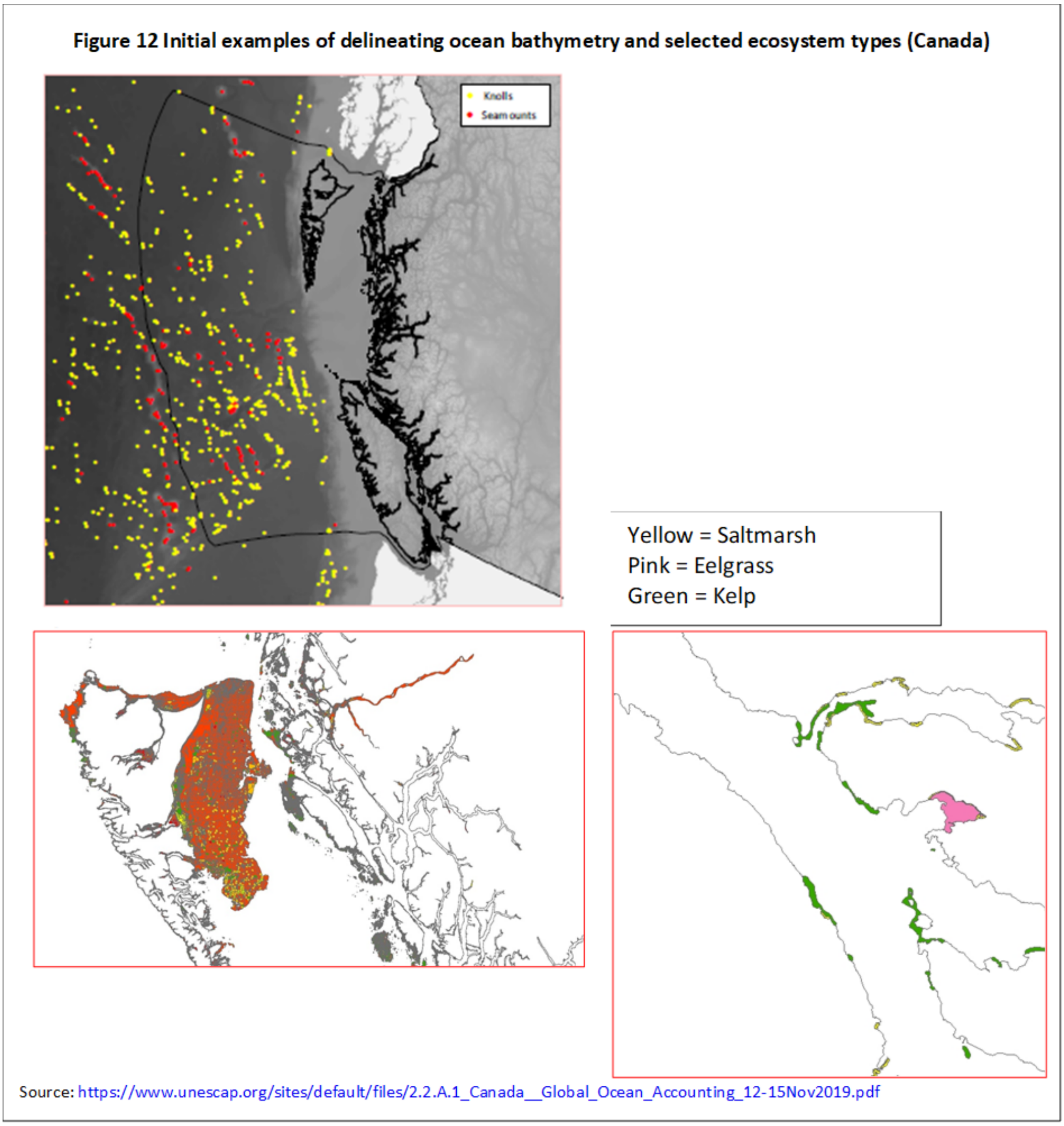


Figure 12. Initial examples of delineating ocean bathymetry and selected ecosystem types (Canada). Source: https://www.unescap.org/sites/default/files/2.2.A.1_Canada__Global_Ocean_Accounting_12-15Nov2019.pdf

- Some key uses of coastal and marine areas include: protected area, designated fishing, tourism, minerals, oil and gas, transportation, aquaculture, and energy production.
- Individual environmental assets include minerals, oil and gas, commercial fish and crustacean stocks, commercial plant stocks, renewable energy potential (wind, wave, tidal). If these have already been

mapped, then the maps could be integrated with the ecosystem extent maps. These may best be produced as a separate map layer and table columns rather than developing a mutually exclusive classification (e.g., seagrasses existing over mineral deposits).

- **Figure 13** provides an example of overlaying ecosystem asset with designated use. The table counts the number of cells of an ecosystem type (e.g., mangrove) that exist within each designated use (e.g., marine protected area). In this case, 4 cells of mangrove exist in marine protected areas.

Figure 13 Simple example of overlaying ocean assets with designated use (ESCAP Exercise)

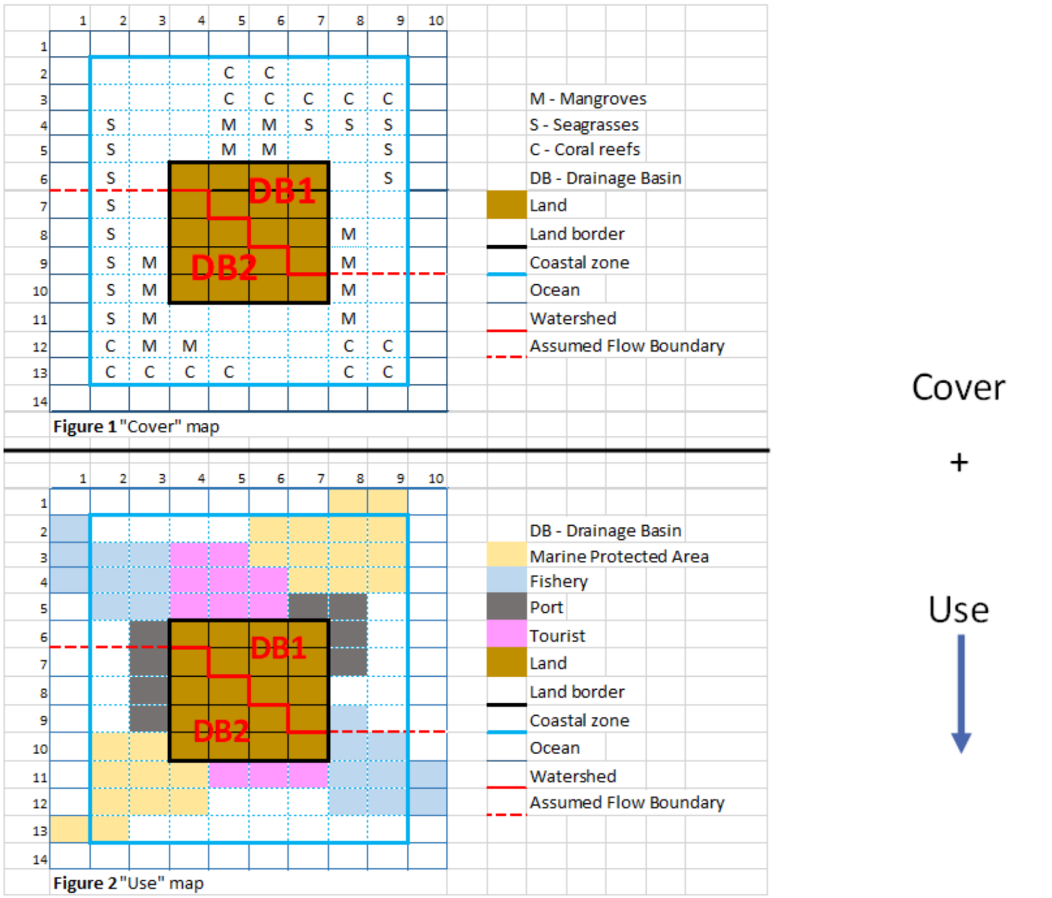


Table 1 Cover by use table

Ecosystem types	Fishery (Unit count)	Port (Unit count)	Tourist (Unit count)	Marine Protected Area (Unit count)	Not in designated use area (Unit count)	Total count (Unit count)
M - Mangroves	3	1	4	4	1	**13**
S - Seagrasses	2	0	0	5	6	**13**
C - Coral reefs	2	0	1	7	6	**16**

A result of overlaying ecosystem type with designated use, Table 1 shows the area of ecosystems within designated use areas (e.g., mangroves within marine protected areas).

Figure 13. Simple example of overlaying ocean assets with designated use (ESCAP Exercise).

Table X. Cover by use table.

Ecosystem types	Fishery (Unit count)	Port (Unit count)	Tourist (Unit count)	Marine Protected Area (Unit count)	Not in designated use area (Unit count)	Total count (Unit count)
M - Mangroves	3	1	4	4	1	13
S - Seagrasses	2	0	0	5	6	13
C - Coral reefs	2	0	1	7	6	16

3.3.3 Key condition variables

- The choice of condition measures will be informed by national priorities and data availability. For example, data on nutrient concentrations would inform concerns about algal blooms or eutrophication. There are many approaches to "reference condition" and these should be agreed and policy relevant (e.g., pristine, sustainable, specific date in the past, pre-industrial, etc.). Generally, reference conditions should be distinct from "target conditions", which may be set by policies, but not necessarily consistent with maintaining or improving capacity to provide optimal long-term ocean services.
- Some key condition variables that would inform multiple ocean-related concerns include:
    - pH (acidity)
    - BOD, COD, Chlorophyll A, primary productivity (an indicator of eutrophication)
    - Species diversity, ecosystem diversity (Shannon index of diversity)
    - Concentration of floating plastics
    - Sea surface temperature (SST)
    - Coral condition (cover, % living, %bleached)
    - Seagrass and mangrove cover (%)
- Individual environmental assets may also be assessed in terms of condition. Minerals have different qualities (high/low grade minerals) and fish stocks can be "heathy" or "unhealthy". Representing these in the condition accounts (**Tables 2 and 3**) would help understand the capacity of those assets to provide services.
- A more extensive list is discussed in **Essential Ocean and Ecosystem Variables**.

3.4 Assessing supply and use of ocean services/inputs to the economy

- Ocean services include both consumptive and non-consumptive use of biotic and abiotic assets. A consumptive service would be the extraction of offshore oil and gas. A non-consumptive service would be the enjoyment of the seascape. Given the many possible ocean services to consider (SEEA-CF natural inputs as well SEEA-EEA ecosystem services), many assessments begin with compiling data on the physical supply and use of the most environmentally, economically or socially significant. Their significance can be informed through the priorities and concerns stated in the Scoping Report.
- Physical flows of some consumptive services, largely flows from SEEA-CF "individual environmental assets", could be estimated from the production of the economic sectors (**Ocean Economy Satellite Accounts**) that supply them: fish catch, fish from aquaculture, aquatic plants, offshore oil and gas, sand and minerals, biomedicines and energy (wind, wave or tidal). These are measured in the physical quantities in which they are extracted, harvested or captured. Initial estimates would likely be made at the national level but could

subsequently be allocated to the sub-national level to establish links to the ocean assets that provide them. For example, sand extraction could be allocated to the coastal beaches from which sand is extracted. Many of these services can be imported, converted into products and used and thereby easily fit into a supply/use structure such as **Table 5**.

- Physical flows of some non-consumptive services can be derived from the extent and condition of the asset that provide them: substrate for transportation by seawater; waste mediation by estuaries; mediation of gas, liquid and gaseous flows by coral reefs, seagrasses, estuaries and rocky shores (includes carbon sequestration and coastal protection); habitats for iconic species, and areas of cultural significance, tourism and recreation by mangroves and open sea. Each of these will have a different set of measurement approaches and conditions under which services are provided. For example, given the types of wastes estimated to flow down the estuary, what proportion will be removed under expected conditions? What ecosystem types and conditions are appropriate for tourism and to what extent are they used?
- Allocating the physical flows of non-consumptive services to the entire asset type from which are derived may overestimate the quantity of the flow. For example, if all coral reefs were attributed the equal amount of “tourism services”, this would not distinguish between those that are more heavily used (or overused) than others. Therefore, it is useful to have a means of allocating these non-consumptive services spatially to the portions of the asset that provide a service that is used. This is also useful for designating the beneficiaries of these services. For example, air purification services by mangroves is provided only when there is a population nearby benefitting from that service.
- Since these non-consumptive services are generally not imported or incorporated into products, tracking their supply and use focusses on establishing the link between the supply (by ecosystem type) and use (beneficiaries) (**Table 6**).
- Ecosystem services often mentioned in ocean ecosystem service assessments (adapted from Bordt and Saner, 2019) include:
    - Provisioning
    - Biomass for nutrition (cultivated and wild animals, plants, algae or fungi)
    - Biomass for materials (cultivated and wild animals, plants, algae or fungi)
    - Genetic materials from plants and animals (pharmaceutical products, genetic inventorying and conservation)
    - Abiotic materials and energy (offshore oil and gas, minerals; wind, wave, solar energy)
    - Abiotic: seawater as a substrate for transportation
    - Abiotic: seawater for drinking or non-drinking purposes (industrial cleaning and cooling)
    - Regulating and maintenance
    - Lifecycle maintenance and habit protection (e.g., fish breeding habitat, habitat for iconic species)
    - Mediation of wastes by estuaries (dilution, filtration)
    - Mediation of mass and liquid flows by mangroves, coral reefs, seagrasses, estuaries, rocky shores (coastal protection from erosion and waves)
    - Atmospheric composition and conditions (carbon sequestration by mangroves, coral reefs, seagrasses, tidal marshes)
    - Cultural
    - Physical and experiential interactions (visits to iconic seascapes)
    - Intellectual and representative interactions (artistic representation of iconic seascapes)
    - Symbolic significance of beaches and open ocean (elements that have a sacred or religious meaning)
- Further examples are provided in **Appendix 6.3**.
- In principle, many of these services have short-term and long-term economic values. However, if there is a market for the services, their values would already have been captured in the SNA and perhaps attributed to the supplier in an ocean economy satellite account.
- It may be best to initially treat the others as non-market benefits and to not value them in economic terms. Consider a stretch of mangrove that protects a coastline from erosion and storms. In a small way, the land being protected may be of slightly higher value with the mangrove (determined using hedonics) since it is at a lower risk from erosion and storm damage. However, the human lives, unique ecosystems and cultural heritage being protected could be invaluable. **Tables 24 and 25** provide a case study example of physical and monetary ecosystem services supply tables.

- **Monetary flow (supply and use) accounts** provides an overview of the SEEA Ecosystems revision thinking on valuation. For example, the best methods[4] to use when data and technical capacity are available include:
    - The service of "fish" is recommended to be valued at the cost of quota/permit fees (rather than the market value of the fish). This focuses on the fishers' willingness to pay to capture fish and is therefore a proxy for the contribution of the ecosystem to the fishers' profits.
    - The service of "carbon sequestration" is recommended to be valued at the current traded value of carbon on carbon trading schemes. If such schemes are not in place, then the "social cost of carbon" (about $50 per ton) could be a proxy.
    - Other regulating and maintenance services are recommended to be valued in terms of "avoided costs" under the condition that the least cost alternative is less than the willingness to pay. "Avoided costs" of storm damage provided by mangroves are the damages to property avoided by the presence of the mangrove. This requires knowledge of the risk to property with and without the mangroves in place. Willingness to Pay (WTP) is the amount affected people are willing to pay to avoid the damage and needs to be determined separately by survey or interview.
    - The contribution of ecosystems to "tourism" is recommended to be valued at the fraction of tourism revenue spatialized based on geotagged social media data. That is, the fraction of tourists visiting a specific ecosystem type is determined by their social media activity. That fraction is then applied to total tourism revenues.
    - The contribution of ecosystems to "recreation" (i.e., nearby use) is recommended to be valued at "simulated exchange value". That is, as though these non-market services were internalized. This requires estimating demand based on non-market valuation techniques such as asking beneficiaries their willingness to pay for the service. This is then combined with knowledge of the supply and market structure (see Caparrós et al., 2017).

ⓘ [4] Many of which are described in detail in http://www.aboutvalues.net/method_navigator/.

- The contribution of ecosystems to "adjacent use" (such as reflected in property value) is suggested to be valued using hedonic pricing using a large sample of property sales data to determine the additional prices of properties being adjacent to desirable ecosystems (e.g., coast, beach, coral reefs, pristine protected area, etc.).
- Many other valuation methods are in use and should be used in ocean accounting with caution. The SEEA revision process has rejected several methods as risking producing misleading results. These methods include:
    - restoration costs (restored ecosystems are unlikely to provide the same services as the one replaced),
    - market prices (for crops, the value of crops includes labour and capital),
    - travel costs (expenditures on travel are difficult to attribute to the area visited),
    - stated preference (estimating consumer surplus without restrictions risks gross overestimations), and
    - unit value transfer without adjustment (benefits transfer is often one by simply allocating the value per hectare from one area to another without adjusting for differences).
- Values based on any the above "rejected" methods should not be used in pilots. If national policies or plans have been based on values using these methods, one objective of a pilot could be to re-estimate the values using approved methods.

3.4.1 Key data sources

- Initial data will likely be compiled at the national level, since it is at this level that national economic planning is done:
    - Physical quantities of natural inputs can often be derived from statistical production surveys conducted by the NSO or resource departments. These surveys are usually used to support monetary supply and use tables for the SNA. If data are available only in monetary terms (e.g., the value of fish,

sand, oil, gas, etc.), then these can be converted to physical quantities if the unit price is known ($/tonne of fish).
  - Resource departments often track physical quantities of the resources extracted, harvested or captured within their mandate. For example, many fisheries departments record catches, energy departments record physical quantities of energy (barrels of oil, m^3 of gas, MWh of electricity), natural resource departments record tonnes or m^3 of minerals, agriculture departments record quantities of aquaculture products.
  - Spatial detail could be added if maps are available of where these natural inputs are extracted, harvested or captured.
- Non-consumptive services that are based on the extent of an ecosystem type, will require maps of those ecosystem types and "factors" to estimate the quantities of services provided per unit. For example, one cubic metre of living mangrove biomass may provide over 200 g of carbon sequestration per year. Applying these factors will require an understanding of how to apply them: some factors refer to the living biomass, others to the total biomass including mud flats. Information on such factors and how to apply them may be available in environment, natural resource or climate change departments.
- There are no global databases of such factors yet available. The IUCN provides an overview of relevant tools including modelling approaches.[5] Factors used in individual case studies are embedded in valuation databases, such as the Environmental Valuation Reference Inventory or TEEB Ecosystem Services valuation Database. Such factors are also embedded in ecosystem services models such as those mentioned in the IUCN document. Ongoing efforts in this space include the Nature Conservancy's Mapping Ocean Wealth and past research on valuation of ecological services across multiple ecosystem types.

[5] The document further recommends http://www.aboutvalues.net/ as a source of additional detail and tutorials. As well, the IUCN recommends the Canadian Ecosystem Services Toolkit.

Table 24. Example of physical ecosystem services supply table (Limburgh province, 2010). Source: Remme *et al.*, 2014. Note: Units are specific to service and cannot be summed across services.

Ecosystem service		Units	**Land cover type**								
			Urban	Pasture	Cropland	Forest	Heath	Peat	Surface Water	Other nature	**Provincial total**
Provisioning	Hunting	kg meat	-	9,100	14,732	8,100	678	70		1,513	**34,193**
	Drinking water extraction	10^3 m^3 water	4,071	7,026	11,227	3,117	214	-	478	862	**26,995**

	Crop production	10^6 kg produce	-	-	1,868	-	-	-	-	-	**1,868**
	Fodder production	10^6 kg dry matter		533	251						**784**
Regulation	Air quality regulation	10^3 kg PM_{10}	272	404	717	700	45	7	40	69	**2,254**
	Carbon sequestration	10^6 kg carbon	875	8,019	273	50,664	393	149	-	1,056	**61,429**
Cultural	Recreational cycling	10^3 trips	2,690	1,863	2,611	1,565	30	3	139	220	**9,121**

Table 25. Example of monetary ecosystem services supply table (Limburgh province, 2010). Source: Remme et al. 2015. Note: Total ES (ecosystem services) values are each modelled using different methods. See original article.

Measure	**Land cover type**								
	Urban	Pasture	Cropland	Forest	Heath	Peat	Surface Water	Other nature	**Province total**
Cover (%)	23.6	20.2	33.9	15.3	1.0	0.3	3.0	2.7	**100.0**
Total ES Value (million €)	4.8	18.6	61.9	19.9	0.9	0.3	1.6	4.9	**112.0**

Average value (€/ha)	90	412	823	587	426	457	239	814	**508**
Standard deviation (€/ha)	277	507	815	473	288	135	313	687	**655**
Minimum value (€/ha)	-	10	14	56	20	21	-	15	**-**
Maximum value (€/ha)	2,900	3,361	4,900	3,226	1,923	653	2,906	3,186	**4,900**
Value public (%)	99	61	18	96	96	97	100	94	**48**
Value private (%)	1	39	82	4	4	3	-	6	**52**

- Drawing physical ecosystem services factors or monetary values from such databases, models or local studies should be done with extreme caution. Each factor or value is based on assumptions about the ecosystem type, the service being measured, the method being applied and the conditions under which the measurement was made. If the conditions are not well documented, then the measure is ambiguous. Furthermore, each measure has its own inherent uncertainty, which may be large. Reducing the ambiguity and documenting the uncertainty of evidence should be a priority for informing decisions.

3.5 Assessing pollutants (flows to the environment)

- If it is a priority to reduce the concentration of nutrients, hazardous chemicals or plastics in the ocean, then understanding the sources of those pollutants will help manage their flows into the ocean. Initial Ocean Accounts could first assess the main ocean pollutant concerns (based on condition accounts) and then select the appropriate flow accounts/tables (see **Flows to the environment accounts**, **Tables 10**, **11** **and** **12**) to understand their sources.
- If equivalent SEEA-CF accounts (water emissions, solid wastes) are available nationally, then these could be allocated to drainage basin (for land-based sources) or marine area (for marine-based sources), using known indicators of economic activity and population. When allocating SEEA-CF accounts, these indicators are used to calculate the proportions of the pollutants generated in each drainage basin or marine area. For example, agriculture generates 5,000t of BOD and Drainage Basin 1 has 60% of the nation's employment in agriculture. The initial estimate for BOD generated by agriculture in Drainage Basin 1 is then 3,000t/year (See **Figure 14**).
- If there are no existing SEEA-CF flow accounts, then estimates could be made by applying per-unit factors to the spatially detailed data on economic activity and population. For example, 5,000 people live in Drainage

Basin 1 and each person is estimated to generate 0.365t of untreated solid waste per year. Therefore, population in Drainage Basin 1 generates 1,825t of untreated solid waste per year. (See **Figure 14**)

- All untreated wastes in a drainage basin do not necessarily flow to the ocean or if they do, they do not necessarily remain where they were deposited. Further analysis of dispersion modelling would be required for more accurate estimates. However, linking the sources with the conditions is a first step.
- Flows to and from other territories may also be of concern. If so, then it would be advantageous for neighbouring countries to conduct similar assessments of flows to the environment.

Figure 14 Simple example of allocating terrestrial activities to drainage basin (ESCAP Exercises)

Example: 5,000 population in DB1 (drainage basin) generates 200m^3/person/year of wastewater, resulting in 1,000,000 in total for DB1.

Table 2a Information of 2 Drainage basins

Pollution Source	DB1		DB2	
	Quantity	Unit	Quantity	Unit
Population	5,000	person	10,000	person
Industry	0.7	proportion	0.3	proportion
Agriculture	0.6	proportion	0.4	proportion

Table 2b Pollution factors

Pollution Source	Wastewater		Solid waste		BOD	
	Quantity	Unit	Quantity	Unit	Quantity	Unit
Population	200	m^3 / person / year	0.365	t/person/year	0.02	t/person/year
Industry	100,000	m^3 / year	1,000	t/year	2,000	t/year
Agriculture	500,000	m^3 / year	2,000	t/year	5,000	t/year

Table 3 Wastewater Production Table

Wastewater production	Population (m^3 / year)	Industry (m^3 / year)	Agriculture (m^3 / year)	Total (m^3 / year)
DB1	1,000,000	70,000	300,000	1,370,000
DB2	2,000,000	30,000	200,000	2,230,000
Total	3,000,000	100,000	500,000	3,600,000

Table 4 Solid Waste Production Table

Solid Waste production	Population (t / year)	Industry (t / year)	Agriculture (t / year)	Total (t / year)
DB1	1,825	700	1,200	3,725
DB2	3,650	300	800	4,750
Total	5,475	1,000	2,000	8,475

Table 5 BOD Production Table

BOD Production	Population (t / year)	Industry (t / year)	Agriculture (t / year)	Total (t / year)
DB1	100	1,400	3,000	4,500
DB2	200	600	2,000	2,800
Total	300	2,000	5,000	7,300

Figure 14. Simple example of allocating terrestrial activities to drainage basin (ESCAP Exercises).

3.5.1 Key data sources

- If SEEA-CF Water Emissions Accounts and Solid Waste Accounts have already been produced, they will have used data from multiple sources (water authorities, environment departments). The same sources could be used to compile estimates in the absence of SEEA-CF accounts.
- Water authorities may publish reports on the concentrations of pollutants in their outflow and the volumes of that outflow. Concentrations of a substance multiplied by water volume equals the quantity of that substance released. For example, 50ppm (parts per million) of BOD in 100 m^3 (tonnes) of wastewater/day would equal 50kg of BOD released per day or 18.25 tonnes per year.
- Environment departments or municipal waste management authorities should have data on the amounts of solid wastes generated by households and various industries, and quantities treated and untreated.
- Agencies for shipping should have data on amounts of pollutants generated (e.g., in bilge water, oil spills) from marine shipping sources.

Samoa, Thailand, and Viet Nam have included coastal tourism in their ESCAP Ocean Accounts pilot studies. Topics covered include not only its contribution to the economy, but also its requirements in terms of water, energy and land and its impacts in terms of generating residuals and impacts on ecosystems. Thailand and Viet Nam benefitted from existing TSAs in the study areas. Samoa, however, developed a “test” TSA by conducting a case study of about 50 establishments. The case study asked establishments their total revenues, total employment and proportion of their revenues from tourism. These estimates were then used to generate initial “partials” that could be applied to the revenues and employment of the sector as reported in national economic statistics.
Similar methods can be used to determine the “partials” of the ocean economy. For example, what proportion of shipping, travel, mining, fishing etc. is attributable to the ocean?

- https://www.unescap.org/sites/default/files/1.3.A.3_Samoa_GOAP_12-15Nov2019.pdf
- https://www.unescap.org/sites/default/files/1.3.A.4_Thailand_GOAP_12-15Nov20199.pdf
- https://www.unescap.org/sites/default/files/1.3.A.5_Viet%20Nam_GOAP_12-15Nov2019.pdf

3.6 Assessing the ocean economy

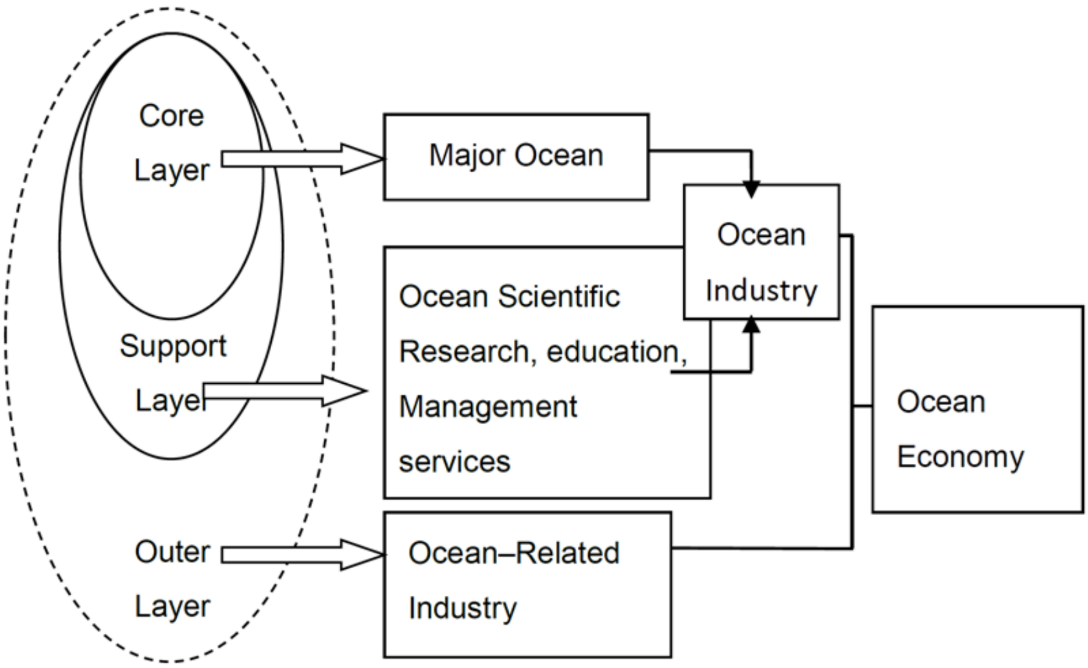
- Countries initiating studies of their ocean economies are advised to begin with identifying the sectors of the ocean economy that are or are expected to be a priority for national development. In many countries, this begins with a focus on marine fisheries, offshore oil and gas, coastal tourism or shipbuilding. The recommended approach to obtain stakeholder agreement on these priorities is to review national plans and policies and engage with stakeholders through the process of developing a pilot project scoping report. The scoping report process should also assess the availability of relevant data, for example as distinct sectors in the SNA or other sources, such as tourism satellite accounts (TSA).
- The first step in creating ocean economy satellite accounts is to define the boundaries of the “ocean economy”. The definition should be able to distinguish between ocean-related and non-ocean related activity using indicators, or “partials” that show the portion of activity related to the ocean in any given industry sector. The definition should be consistent with other national economic statistics series so that the ocean portion can be correctly placed into context. It should also be capable of consistent measurement over time so that trends can be identified, and over space so that the measurement of the ocean economy in one part of a country is consistent with measurements in other parts. Adhering to detailed definitions also facilitates comparison with other countries.
- In developing the estimation methods for ocean economy satellite accounts, care should be taken to choose approaches that can be regularly replicated. Ocean economy satellite account development is often started with the most easily available data. However, such data may be based on one-time studies of specific industries or ocean assets. Using such data can prevent repeated measurements of sufficient quality to provide useful trends. Surveys and administrative data of sufficient statistical quality are ultimately the most appropriate source.

- A detailed definition of the ocean economy is the basis for compiling tables, such as the example provided in **Table 13**. The characteristic economic activities included by other countries in their ocean economy satellite accounts are discussed in **Ocean economy satellite accounts** above (**Table 14**) and other examples are provided in **Appendix 6.6**.
- Tourism, since it is embedded in many sectors (accommodation, food and beverage, transportation) may require the estimation of an initial tourism satellite account (TSA). That is, what proportion of these sectors can be attributed to tourism, especially coastal tourism. For countries with existing TSAs, and with substantial non-coastal tourism, it will be necessary to distinguish between coastal and non-coastal activities.

3.6.1 Measures of economic activity

- The focus to date in ocean economy satellite accounting has been on gross value added (GVA, the value of output less the value of intermediate consumption, see OECD Glossary of Statistical Terms) as the principal measure of ocean-related economic activity. As Table 26 shows, the majority of national ocean economy satellite accounts described in a survey by the OECD use GVA as the principal measure of economic activity.
- Gross value added (GVA) has several advantages for measuring ocean economic activity. It is additive across industries from very specific industries to very broad sectors. It is also additive from subnational to national levels. GVA permits the ocean economy to be described in terms of different "layers" as China does in its ocean accounts, as depicted in **Figure 15** with "core", "supporting" and "outer" layers.
- However, counting only the value added of specified industries in the ocean economy provides a partial view of the role of the ocean in the national economy. A more complete measures is gross output (GO), essentially the total sales of each industry, since GO includes the value of intermediate inputs. It is for this reason that GDP, the broadest measure of annual market-based economic activity, is usually determined by valuation at final demand. That is, the value determined at the point of the ultimate purchaser as defined by four groups: consumption, investment, government, and net exports (exports minus imports). At the point of final sale all the inputs and their value added are accounted for.
- GDP or GO has the advantage of breadth of inclusion of all economic activity related to the ocean and all of the inputs to that output, but it may result in double counting the same industry output if reported at the level of detail many countries are using. Value added avoids double counting but misses intermediate input values to ocean industries which are not specifically defined as part of the ocean economy. Both approaches are valid measures of the ocean economy and may be used together; indeed, comprehensive national income accounts should contain both as noted below. Alternately, one approach may be chosen as a starting point. GVA is the most common measure largely because it can most easily be specified by industry within the limits of industrial taxonomies used. It should be noted that the ISIC taxonomy is limited in the industrial detail available, compounded by the fact that national implementation in many countries remains coarse-grained.

Figure 15 Relationship among concepts of ocean economy in China



Source: Wang, 2016

Figure 15. Relationship among concepts of ocean economy in China. Source: Wang, 2016.

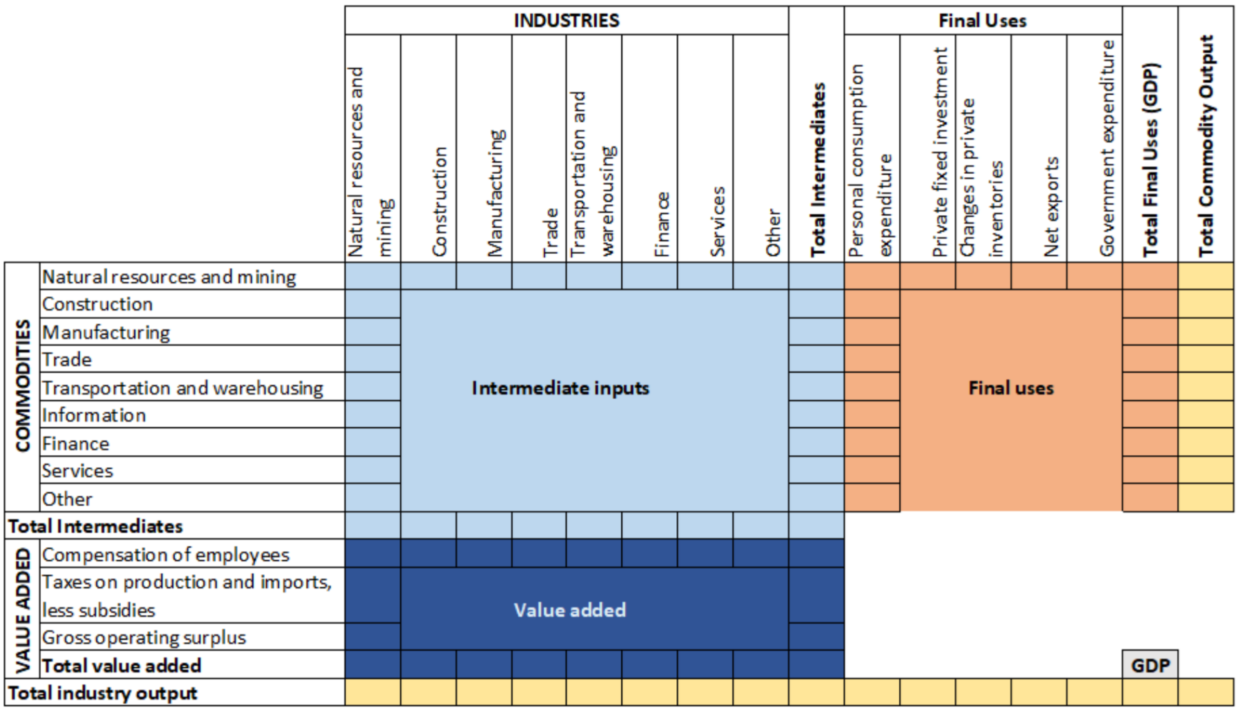
Table 26. Selected estimates of value of ocean-based industries, by country, region and world. Source: OECD, 2016.

Country	Author	Date of study	Date of data	Contribution of ocean sectors to GDP or GVA	% of GDP or GVA	Employment (total FTE)
Australia	Allen Consulting Group	2004	1996-2003	AUD 26.7 bn GVA	3.6% GVA	253 130
Belgium	Flander's Maritime Cluster	2011	2010	..	10% GDP	..
Canada	Gardner Pinfold Consulting	2009	2006	CAD 17.7 bn GDP	1.2% GDP	171 365
	Acton and White Associates	2001	1998	CAD 10.4 billion GDP	1.4% GDP	120 000
China (People's Republic of)	APEC	2014	2012	..	9.6% GDP	..
	Jiang et. al.	2014	2000-11	..	13.83% GDP	..
	CMIEN	2013	2012	CNY 5 0087 tn GDP	9.6% GDP	34 0240 000
	Zhao, Hynes and He	2013	2010	CNY 239.09 bn GVA	4.3% GDP	9 000 000
Dubai	Gujarat Maritime Board	2014	2013	..	4.6% GDP	..
France	Kalaydjian et al.	2009	2007	EUR 28 bn GVA	1.4% GDP	484 548
	Kalaydjian et al.	2011	2009	EUR 26 122 bn GVA	2.5% GDP	460 163
	Kalaydjian et al.	2014	2012	EUR 30 252 bn GVA	2.75% GDP	460 396
Hong Kong (China)	Gujarat Maritime Board	2014	2013	..	25% GDP	..
Iceland	Sigfusson and Gestsson	2012	2010	..	26% GDP	ca. 30 000
Ireland	Vega, Hynes and O'Toole	2015	2012	EUR 1.3 bn GVA	0.7% GDP	17 425
	Vega, Hynes and Corless	2013	2010	EUR 1.2 bn GVA	0.7% GDP	16 614
Japan	Nomura Research Institute	2009	2005	JPY 7 863 bn GVA	1.6% GDP	981 234
Korea	APEC	2014	2005	..	8% GDP	..
	Hwang et al.	2011	2008	KRW 13 435 bn GVA	4.9% GDP	919 314
Netherlands	Maritime by Holland	2014	2012	EUR 21 bn GVA	3.3% GNP	224 000
New Zealand	Statistics New Zealand	2006	1997-2002	NZD 3.3 bn GVA	2.9% GDP	21 000
Portugal	DGPM	2013	2010	..	2.5% GVA	..
Singapore	MPA – Maritime Singapore	2014	..	..	7% GDP	..
United Kingdom	Pugh (2008)	2008	2005-06	GBP 46 041 bn GVA	4.2% GDP	890 416
United States	Kildow et. al. (2014)	2014	2010	USD 258 bn GDP	4.4% GDP	2.8 million
Europe	Ecorys	2012	2011	EUR 495 bn GVA	..	5.6 million
Worldwide	Hoegh-Guldberg et al.	2015	2011-14	USD 2.5 trillion "gross marine product"	3.2% GDP	..

- Another distinction between GVA and GO for ocean economy satellite accounts is that GVA involves identifying industries and aggregating the ocean economy **up** from these. GO requires taking the measures of output measured at final demand and disaggregating **down** to the ocean-related components. To do this disaggregation requires:
    - identification of "direct ocean-related industries"
    - the share of these industries' output that is ocean related, termed a "partial", and
    - the use of input-output tables to measure the complete list of outputs of industries used by the primary ocean outputs.
- The designation of "direct" ocean industries, or "core" industries (to use the Chinese term) is a matter of judgment for each country. The coefficient of ocean relationship (termed a "partial") can be easily measured for some industries (such as marine fishing or transportation, (in which case the partial is 1). But it may be more difficult for other industries such as boat building where boats may be used in inland settings or in ocean settings. In such cases, other data will need to be used; in the boating example, data on boat registrations might be used.
- The third element of the ocean-GDP uses the input-output tables. Figure 16 illustrates the basic structure for the overall national income and product accounts, in this case from the United States Bureau of Economic Analysis.

- By designating the primary ocean industries in the “Final Uses” section of the table, all intermediate inputs in all industries in that section of the table can be measured; significant improvements in the measurement of the ocean relationship can be realized by also designating ocean relationship coefficients (partials) for these inputs. Note that GVA for industries can also be measured at the same time if value added tables are incorporated in the system of input-output tables.
- Constructing the ocean economy satellite accounts within the structure of the I-O tables allows a complete measurement of both the economic activity defined as directly related to the ocean and the complete range of supporting (intermediate) inputs, some of which may be selected for note as part of the ocean economy consistent with the definition selected. **Figure 16** uses very broad definitions of sectors, but in the creation of an ocean economy satellite account, more refined definitions are used. In the U.S. case, an I-O table estimated using over 8,000 product groupings are used and a subset of these is selected for definition of an ocean relationship using “partials”.

Figure 16 Basic structure of national income and product accounts



Source: US Bureau of Economic Analysis.

Figure 16. Basic structure of national income and product accounts. Source: US Bureau of Economic Analysis.

- The use of GVA and Final Demand (the value of output measured at the point of ultimate purchase) addresses the value of ocean economic activity in the current period. Generally, ocean economy satellite accounts are estimated annually, though some countries also provide quarterly GDP estimates, which may include ocean-related components or not depending on the level of effort in measurement of the components of the ocean GDP.
- However, current period economic activity is only one part of a comprehensive set of accounts, which should take account of both flows (transactions in a given period) and stocks, or the change in the value of capital (produced) assets between the beginning and end of a period. Changes in the value of capital assets

reflect an economy's ability to accumulate or deplete resources needed for the generation of future flows. In SNA accounting, the changes in the stocks of capital each year are measured as the "private fixed investment", which identifies additions to capital. Depreciation of capital is also incorporated in the national income accounts to reflect the deterioration of capital such as buildings and equipment. It can also include losses in capital from forces such as natural disasters. This same logic is used in the environmental and ecosystem service accounts to measure positive and negative changes in "natural capital".

- Most ocean economy satellite accounts are not yet identifying changes in produced capital or related financial capital. China is an example of a country which does include an ocean capital account in its system (**Figure 17**). Integrating produced and financial capital into the ocean economy satellite accounts framework will be an area for future research.

Figure 17 Components of the ocean economy

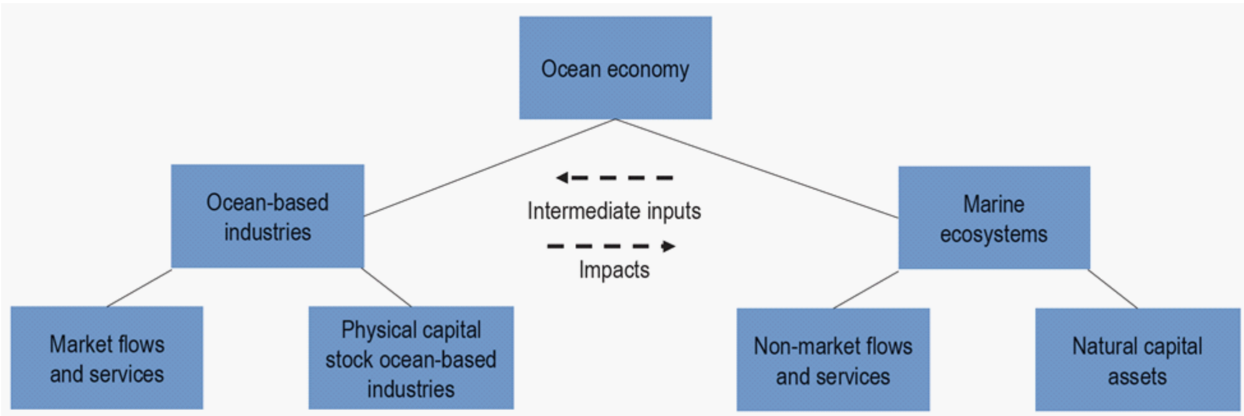


Figure 17. Components of the ocean economy. Source: OECD, 2017.

3.6.2 Ocean-related employment

- One additional measure of economic activity that is commonly used is employment. Employment is measured by various combinations of administrative records (for example in the administration of unemployment insurance systems) and surveys of firms and individuals. While output is cumulative over a period, employment can be highly variable within and between periods and is not measured cumulatively. In many ocean industries, such as fishing and tourism, there can be very high levels of seasonality, which are rarely captured in the annual ocean economy satellite accounts. Moreover, employment in many key sectors of the ocean economy is characterized by very different arrangements than traditional employment. Employment is a particularly difficult concept with self-employment and subsistence or non-market employment, a common feature of fisheries in many parts of the world. Particular attention must be paid to the organizational structure (corporations, small proprietors, self-employed) to measure fishing related employment In other parts of the ocean economy such as marine transportation, the employment is recorded in one country (the flag country), takes place in other countries or in international waters, and the wages generated are sent to yet another country.
- Ocean accounts provide a basis for addressing the spatial nature of the relationship between people and the ocean in terms of dependence and risks. Social data disaggregated by location and social sub-groups will provide a means of identifying priorities for intervention. It is important to note this section addresses only one aspect of social concerns and disaggregation. Other aspects are discussed throughout the document and can be found, for example, in **Section 2.8.6**, **Section 3.6.1**, and the Table in **Appendix 6.4**.

3.6.3 Key data sources

- Information on the contribution of the fisheries industry, derived from economic surveys, will likely already be included in the national accounts. The fishing industry, as represented in the SNA may not cover small-scale and recreational activities and these may require special surveys or estimation from administrative data. Other sectors that may be easily extracted from the SNA include offshore oil and gas, boat and ship building, marine transportation and marine-related construction (such as ports).
- The data needed to construct ocean economy satellite accounts starts with each country's SNA accounts. However, these accounts are rarely well suited to the demands of identifying ocean-related activities. Other data series such as natural resource outputs (value of fish landings), marine transportation[6], or, if available, regional data that permits differentiating between inshore and offshore activities areas such as tourism to be identified can be used. The most rigorous approach would be through surveys of firms either specific to the estimation of ocean economy satellite accounts (the approach taken in China) or an adaption of other economic surveys used to construct national economic accounts.
- Developing comprehensive ocean economy satellite accounts requires adding detail to the SNA in terms of economic sectors and commodities. As well, it requires guidelines to avoid double counting, to apply appropriate methods of valuation and to appropriately scope the results to distinguish economic activities in ABNJ.
- Specific data sources exploited in the compilation of ocean economy satellite accounts will vary by country. Each country has its own level of detail in the SNA and its own conventions about confidentiality of the detailed data. For this reason, it is highly recommended that initiatives to compile ocean economy satellite accounts be done in close collaboration with the NSO. The exercise could encourage adding detail to existing economic statistics in future years.
- As an example of a moderately complex compilation of ocean economy satellite accounts in Canada, **Table 27** indicates the data sources used for some of the key sectors.

[6] Assessing the value of marine transportation is complicated by boundary issues, and does not equate to the value of the goods transported (computers, oil, wheat, etc.) Rather, the value of marine transportation is measured in terms of the value added of port services (loading and unloading ships, transferring goods from the marine transport network to the land transport network, storage, etc). The value associated with movement of goods across the ocean can be measured as the value added of shipping companies. The income accruing to these companies are often located in a different country than the port. Labour contributions often come from all over the world. Detailed assessments of the full value added from marine transportation apportioned to the multiple relevant countries are scarce.

Table 27. Indicative data sources for Canada's Marine Economy Accounts. See: https://www.dfo-mpo.gc.ca/stats/maritime-eng.htm. Note: The compilation is conducted by Fisheries and Oceans Canada, with no access to confidential Statistics Canada data. All statistics are disaggregated by at least 3 regions (Atlantic, Pacific, Arctic) and some by province. *SNA tagged items may be directly from principal statistics series or from supporting production surveys.

Sector	Data source
Private sector	
Fishing and Seafood	

Commercial fishing	Since regional detail not available from SNA*: Departmental statistics on sea fisheries landings, fisheries management plans, catch data (by province)
Aquaculture	Statistics Canada Aquaculture Statistics (production survey)
Fish processing	SNA, export data
Offshore oil & gas	
Oil & gas exploration / extraction	Petroleum boards Some sourced from construction and capital expenditure surveys
Transportation	
Marine transportation	SNA and customs data on transportation revenue flows
Support activities	From input-output and customs data
Tourism and recreation	
Recreational fishing	Survey of recreational fishing (expenditures); adjusted for saltwater
Recreational boating	Marine manufacturers association recreational boating report
Cruise ships	Business association reports
Coastal tourism	Estimated from Statistics Canada travel survey
Manufacturing and construction	
Shipbuilding and boat building	SNA
Ports and harbours construction (public)	Government financial reports
Public sector	

Federal and provincial government	Marine-related and coastal expenditures derived from financial reports (removing contributions to marine-related transportation and construction)
Universities	Ocean-related grants plus expenditures of coastal universities
Environmental non-governmental Organizations (ENGOs)	Financial data of representative ENGOs

3.7 Assessing ocean governance

- "Governance" refers to the ways in which individuals and institutions manage their common affairs. The ocean is a common asset and managing the impacts people have on it requires an understanding of the norms, institutions and relationships involved.
- The basic outline of ocean governance should already be included in a national Diagnostic or Scoping Report. Relevant components of the Diagnostic Tool (**Prioritisation and account development planning**) record information about:
  - Statement of Strategy and Policy Priorities: The "norms" as encoded in:
  - the national vision, as stated in the constitution or national sustainable development plans and strategies
  - relevant policies, including sector-specific (e.g., and ocean policy, strategy, MSP or ICZM) or related policies: sustainable development strategy, national biodiversity strategy and action plan (NBSAPs), multilateral environmental agreements (MEAs), Nationally Determined Contributions on climate change (NDCs), Voluntary National Reviews on SDGs (VNRs), sustainability concerns, such as problems that need to be resolved or avoided in the future
  - **Institutions and their mandates and data holdings related to the ocean**: There may be one institution responsible for coordinating government activities on the ocean or the responsibility may be spread across many agencies. NSOs may see their stakeholders as "data providers", but users and affected stakeholders and international agencies also need to be considered.
  - **Relationships, including institutional mechanisms and data sharing arrangements**: There may be senior committees or technical working groups with the mandate to coordinate information and actions on the ocean. Coordination mechanisms responsible for sustainable development or environment may also have responsibility for the ocean.
- **Ocean Governance Accounts** suggests codifying this information spatially and by sector; that is, to what areas of national waters and which sectors do specific mandates, information holdings and coordination mechanisms apply. This would be an opportunity to assess whether all national waters are covered by relevant mandate.
- Reviewing relevant policies will help understand (a) whether the policies are coherent with the national vision and development goals, (b) whether they address the stated concerns about the ocean (e.g., overfishing, pollution) and (c) what data are required to monitor and report on their targets.
- Reviewing stakeholder data holdings, using the ESCAP Environmental Data Inventory Template will help understand the nature of the data available in terms of topic, coverage, quality and accessibility.
- Combining these reviews of policies and data holdings will begin to identify gaps in both. Are the policies addressing the concerns? Are data available to monitor and report on the policy targets? ESCAP's EPIC (Every Policy is Connected) tool suggests a collaborative process for identifying such gaps. ESCAP is also testing a tool for Accelerating Implementation of SDG14 by identifying and addressing gaps and bottlenecks in policies and institutional mechanisms.

- Such analyses could help identify priorities for a pilot study. For example, in Samoa and Thailand policies were in place to increase the benefits from tourism. The pilot studies began to assess the resource requirements and impacts of tourism to develop analyses of possible future scenarios. For example, if tourists generate four times the waste of residents, what infrastructure would be required to manage waste from twice the number of tourists?
- Assessing governance also means measuring the effort put into monitoring, managing and mitigating impacts on the ocean. A country could have many extensive plans in place, yet not have enough people and funds to implement and monitor them. The SEEA-CF provides guidance for measuring environmental protection expenditures (summarized in **Table 16**). The FDES (**Appendix 6.4**) suggests recording the number of employees engaged as well.

3.7.1 Key data sources

- Many national and institutional constitutions, policies, plans, priorities, strategies are posted online, but ongoing processes, such as discussions on an ocean strategy, may not be readily available. Also, departmental mandates and data holdings may be online.
- Information on ocean governance may already be summarized in an NBSP, State of the Environment Report (SOER), FDES compendium or VNR (Voluntary National Review). If the NSO is engaged in SDG reporting, they should have an overview of national data holdings related to the ocean.
- ESCAP has produced an assessment of SDG14.2.1 (*Proportion of national exclusive economic zones managed using ecosystem-based approaches*) in terms of progress in MSP by coastal member States in Asia and the Pacific. It includes detailed information on national MSP and ICZM-related activities, policies, plans and strategies. IOC-UNESCO provides a more summary, global assessment[9].

3.8 Compiling summary indicators

- The outputs of an ocean accounting pilot study will most likely include several detailed tables on ecosystem extent, condition, and services with respect to the issue and study area being addressed. However, providing policy-relevant summary indicators will ensure that the results of the study are easy to communicate. Part of this communication should also include an assessment of data quality and availability. The detailed tables and databases used to produce the Ocean Accounts will serve to "drill down" into the locations and specific measures underlying the summary indicators. This would contribute to the compilation of tables in **Combined Presentation** and **Ocean Wealth Accounts**, such as **Tables 19**, **20** and **21**.
- The summary indicators should address the topic of the study and put the study in context.
- The Framework for the Development of Environment Statistics (FDES) also provides recommendations on several ocean-related indicators as part of the overall framework measuring the state of the environment, our dependence on it, our impact on it, it's impact on us and what we are doing to manage those impacts. See **Appendix 6.4** for a detailed list of these indicators.

Table 28. provides an overview of some summary indicators that could address the topics in the pilots mentioned earlier.

Topic	Summary indicator	Context	Quality concerns

The value of the ocean economy	Annual production value by resource type (market vs non-market) and ecosystem type; Resource values at risk (cost to economy of no action on rehabilitation or protection of key ecosystems)	Proportion of value of national economy · Possible economic losses (in % of GDP) if ecosystems not rehabilitated or protected. Possible impacts on target populations (low-income, small-scale fishers)	Estimations required; valuation methods used
Non-market ocean services	Physical measures of regulating and maintenance services (coastal protection, flood mitigation, carbon sequestration, water purification, etc.)	Proportion of essential ecosystem services provided by the ocean (i.e., compared with terrestrial assessments);	Applying one factor to ecosystem types of varying conditions; Appropriateness of global factors used to value local ecosystems;
Ecosystems extent and/or designated use	Area of ecosystem types and uses of concern; Change in area (e.g., decline in mangrove; increase in MPA)	Proportion of national EEZ (e.g., MPA)	Areas where ecosystem type is unknown; Uncertainty in maps (resolution, inconsistencies); Vintage of data
Land-based sources of marine pollution linked to ecosystem condition	Most significant location and industry of pollutants of concern; Condition of ecosystems affected by pollutants of concern;	National proportion of unmanaged pollutants; Proportion of land-based pollutants flowing to ocean; Locations and extent of pristine and degraded ocean ecosystems.	Estimates of pollutants based on proportion of economic activity or population. Availability of data on condition of marine ecosystems.
Resource requirements and impacts of tourism and other marine-based sectors such as shipping, fisheries and mining	Resource requirements of current and planned tourism (water, energy, land); Current and probable impact of ocean tourism (waste, habitat degradation);	Value of current and planned tourism with respect to overall economy; Resource requirements and impacts of alternative forms of tourism (cultural, agricultural, urban)	Estimating resource requirements and impacts of tourism based on small-sample surveys; Distinguishing ocean tourism from other tourism;

4. Use and maintenance of Ocean Accounts

Table of Contents

- This section provides guidance relevant to the ongoing maintenance of Ocean Accounts (including the generation of time series), and the use of Ocean Accounts to inform ocean governance. Particular attention is devoted to producing indicators, data sources, policy and governance use cases, research use cases, and enabling factors such as institutional, regulatory, and legal frameworks.

4.1 Indicators for sustainable development

- This section presents a general discussion of the importance of indicators for sustainable development policy, linking to the Summary Indicators table of Section 3.8.

4.1.1 SDG Indicators

- To keep track of progress against the 17 Sustainable Development Goals and 169 associated targets, the Interagency and Expert Group on SDG Indicators (IAEG-SDGs) developed a framework of over 200 indicators, which was adopted by the UN General Assembly in July 2017. Countries are leading on the delivery of the SDGs, on a voluntary basis, and are encouraged to use the framework of globally agreed indicators to report on progress. This will require a significant level of capacity and resources from countries: many indicators do not currently have internationally established methodologies nor available data and/or associated monitoring schemes in place. Countries are encouraged to prioritise and develop their various monitoring schemes over time, in accordance with their national capacities.

- To facilitate the implementation of the global indicator framework, the indicators have been classified into three tiers based on the global availability of methodologies and data (see **Table 29** for tier classifications). Tier classifications are reviewed annually based on changes in methodologies and data availability and progress in the development of the indicators (as documented in associated work plans).

Table 29. Tier classification criteria and definitions for SDG indicators.

Tiers	Tier classification criteria / definitions
Tier 1	Indicator is conceptually clear, has an internationally established methodology and standards are available, and data are regularly produced by countries for at least 50 per cent of countries and of the population in every region where the indicator is relevant.
Tier 2	Indicator is conceptually clear, has an internationally established methodology and standards are available, but data are not regularly produced by countries.
Tier 3	No internationally established methodology or standards are yet available for the indicator, but methodology/standards are being (or will be) developed or tested. *(As of the 51st session of the UN Statistical Commission, the global indicator framework does not contain any Tier III indicators)*

- Currently, there are few consistent approaches for data collection and reporting for global targets such as the SDGs, or the Aichi Targets of the UN Strategic Plan for Biodiversity (2010-2020). While social and economic data might be collected by National Statistics Offices in the countries, environmental and ecological data are often collected by Non-Governmental Organisations and research institutes at country, regional or even global levels. To support the global reporting process for SDGs, the Inter-Agency and Expert Group on SDG Indicators (IAEG-SDGs) is developing guidelines on data and information flows from national to global levels.
- According to the IAEG-SDGs reporting guidelines, the monitoring data underlying the indicators will be collected and processed at the national level by relevant public and private-sector institutions, and brought together in reporting platforms by the National Statistics Office of the country. From here, the data and information will be transmitted to international agencies, either directly or through regional mechanisms such as the Regional Seas Programmes. The international agencies will then aggregate the country-level data at regional and global levels and submit these aggregates, along with the country data, into the Global SDG Indicators Database, which is maintained by the UN Statistics Division (UNSD). **Appendix 6.5** provides an initial link between the SDG indicators and the Ocean Accounts Framework.
- UNEP has developed a provisional Global Manual on Ocean Statistics which focuses on supporting countries in their efforts to track progress against the delivery of SDG14 and the specific indicators under UN Environment custodianship:
    - 14.1.1 Index of Coastal Eutrophication (ICEP) and floating plastic debris density.
    - 14.2.1 Proportion of national exclusive economic zones managed using ecosystem-based approaches.
    - 14.5.1 Coverage of protected areas in relation to marine areas.

4.1.2 Other indicator frameworks

- The Framework for the Development of Environment Statistics (FDES) is a multi-purpose and statistical framework that conceptually defines the scope of environment statistics compatible with other frameworks such as the SEEA and the Driving force-Pressure-State-Impact-Response (DPSIR). It contains six components, 21 sub-components, 60 statistical topics and 458 basic statistics intended as a guide to the collection compilation of environment statistics particularly at the national level. The basic statistics also are organized into three tiers based on the level of relevance, availability and methodological development as follows:

    - Tier I or so-called core set of environment statistics (100 statistics) – high priority and relevance to most countries and have a sound methodological foundation.
    - Tier II (200 statistics) – relevance to most countries but require greater investment of time, resources or methodological development.
    - Tier III (158 statistics) – lower priority or require significant methodological development.
    - The FDES was endorsed by the 44th session of the Statistical Commission in 2013.
- Ocean Health Index (OHI) measures the state of the world's oceans in ten categories or "goals", namely food provision, artisanal fishing opportunities, natural products, carbon storage, coastal protection, tourism and recreation, coastal livelihoods and economies, sense of place, clean waters, and biodiversity. In each goal, four dimensions of status, trend, pressures, and resilience are assessed using globally available, mutually non-exclusive sets of indicators. The OHI is presented in 236 regions including 221 coastal countries/ territories and the Antarctic for which the assessment covers inland to one kilometre from the shore and seaward to either three or 200 nautical miles (Exclusive Economic Zone, EEZ), and 15 High Seas areas. The global score is an area-weighted average of the scores of all regions.
- The Global Ocean Observing System (GOOS) is a coordination system of global ocean observations – situ networks, satellite systems, governments, UN agencies and individual scientists – on climate, operational services, and marine ecosystem health. It establishes "Essential Ocean Variables" (EOV's) as a framework to coordinate efforts, avoid duplication, and set common standards for data collection and dissemination among different ocean observing networks and systems. There are 31 EOV's and more than 100 sub-variables as of April 2020.

4.1.3 Disaster risk indicators

- The Sendai Framework for Disaster Risk Reduction 2015-2030, the successor to the Framework for Action (HFA) 2005-2015, was adopted at the World Conference on Disaster Risk Reduction held in Sendai, Japan and endorsed by the United Nations General Assembly in 2015. The framework sets out seven measurable targets to monitor progress towards its goal and expected outcome of reducing existing and preventing new disaster risks. The seven targets include:
    - Substantially reduce global disaster mortality by 2030, aiming to lower average per 100,000 global mortality between 2020-2030 compared to 2005-2015;
    - Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 between 2020-2030 compared to 2005-2015;
    - Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030
    - Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030;
    - Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020;
    - Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of this framework by 2030; and,
    - Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030.
- An internationally agreed set of 38 indicators were specifically developed to track progress of the seven global targets. The Sendai framework also contributes to measuring relevant targets and indicators of SDG 1, 11 and 13. The United Nations Office for Disaster Risk Reduction (UNDRR) is mandated to provide support to the implementation, follow-up, and review of the Sendai Framework. Disaster-related statistic framework (DRSF) complements the Sendai framework and SDG indicators by providing measurement and implementation guidance including definitions, classifications, concepts, and methodologies to integrate and harmonize statistics for disaster risk reduction. It proposes a basic range of disaster related statistics

covering key statistics before, during and after an emergency event. ESCAP provides secretariat support to the development of the DRSF.

4.1.4 Climate change indicators

- The UNECE CES Task Force on core climate change-related indicators and statistics has updated a set of related key climate change-related statistics using the SEEA and other statistical frameworks for implementation in the European region. The refined set of core climate change-related indicators contains 44 indicators – compared to an initial set of 39 core climate-change related indicators and statistics endorsed by the CES in 2017 – covering five climate change areas namely Drivers (9 indicators), Emissions (9 indicators), Impacts (13 indicators), Mitigation (8 indicators) and Adaptation (5 indicators). It also proposes the inclusion of operational indicators, contextual indicators, and the core climate change-related statistics.
- Out of the 44 indicators, 8 are SDG indicators; 4 are conceptually identical to the Sendai framework; and 25 can be produced from the SEEA-CF and SEEA-EEA. At the global level, UNSD has initiated the development of a global set of climate change statistics and indicators since 2016. The global set will contain a list of climate change statistics/indicators consistent with exiting relevant indicator frameworks, including the UNECE CES set of core climate change-related indicators, and covering five IPCC areas: drivers, impacts, vulnerability, mitigation and adaptation. An initial set has been drafted and piloted by selected countries and international/regional organizations. The global consultation is being planned to be undertaken in mid-2020.

Table X. Number of core climate change-related indicators per area and sub-area. *The set of core indicators intentionally does not break down drivers and emissions according to economic sectors.

	Areas				
Sub-area	**Drivers**	**Emissions**	**Impacts**	**Mitigation**	**Adaptation**
National total	6	5	1	-	-
Production	2	2	0	-	-
Consumption	1	2	0	-	-
Physical conditions	-	-	3	-	-
Water resources	-	-	1	-	1
Land, land-cover, ecosystems and biodiversity	-	-	3	0	0
Human settlements and human health	-	-	4	-	1

	Areas				
Sub-area	**Drivers**	**Emissions**	**Impacts**	**Mitigation**	**Adaptation**
Agriculture, forestry and fishery*	-	-	1	1	2
Energy resources	-	-	-	2	-
Environmental governance and regulation	-	-	-	4	0
Expenditures	-	-	-	1	1
Total	**9**	**9**	**13**	**8**	**5**

4.2 Data sources and platforms for Ocean Accounts

- This section provides a more comprehensive treatment of data sources, building on the more specific guidance provided in Chapter 3. As advised in Chapter 3, there is a broad range of national data that can be exploited to compile ocean accounts, including:
    - existing statistical data such as the SNA, Census and social surveys, ongoing SEEA-CF and SEEA-EEA accounts such as solid waste, land, ecosystem condition, water, energy, environmental activities, ongoing compilations such as environmental compendia using FDES,
    - existing geospatial data, such as national land cover maps,
    - existing administrative data, such as fish catch or mine production statistics.
- These existing data can be repurposed for use in ocean accounts. However, existing data may not be sufficient to compile the accounts that have been designated as priorities. In these cases, compilers may need to explore alternative sources, such as global geospatial and monitoring data. As well, they may need to apply estimation methods, including modelling, to fill gaps or build scenarios of future conditions.
- This section provides insights into ongoing efforts to inventory, integrate and make available data on the ocean including:
    - improving the collection, integration, and applying **A digital ecosystem for the environment**
    - new developments in **Earth observation data**
    - ongoing work to develop **Essential ocean and ecosystem variables**
    - developments in national and international **Fisheries data**
    - insights into data on **Socio-economic conditions**
    - a review of **Data platforms** (that is, large data collections available online)
    - using **Modelling** to fill data gaps or make estimates about the future, and
    - suggestions for a set of **Core ocean statistics** selected to be globally applicable and feasible

4.2.1 The case for digital ecosystem for the environment

- In the discussion paper "The Case for a Digital Ecosystem for the Environment" (Jensen & Campbell, 2019), UN Environment makes a compelling case on how data, technology and innovation can transform the way environmental data are collected and managed, and thus can critically enable conditions for better governance.

- As reported by the UN Secretary General's Independent Expert Advisory Group on a Data Revolution for Sustainable Development, without high quality geospatial data, the task of designing, monitoring, and evaluating effective policies to achieve the Sustainable Development Goals (SDGs) is almost impossible. The same concept can be applied to Ocean Accounting, whereby new data management technologies, artificial intelligence, cloud computing and cloud storage of information, together with increased volume of accessible geospatial data, are making it possible to manage, share, process and analyse large volumes of data in near real time as well democratizing access to the data itself.
- The digital ecosystem proposed by UN Environment would comprise of the following four main components: *(1)* data; *(2)* infrastructure; *(3)* algorithms and analytics; and *(4)* insights and applications. Following this, an Ocean Accounting platform would transform data using an underlying infrastructure combined with algorithms and analytics (i.e. models) into insights and applications that are used by National Statistics Offices and other stakeholders.
- **Data**: the volume of data currently being generated is so high that we are now accustomed to referring to it as "Big Data". This term refers to large volumes of data that cannot be processed effectively with traditional applications. Big Data availability is however non-homogenous, as there are a wide variety of different sources (e.g. Earth observation remote sensing and *in-situ* platforms, citizen science, administrative and financial data, etc.) types (covering different spatial and temporal resolutions), quality, and formats.
- **Infrastructure**: In order to manage this large volume of data a distributed infrastructure is needed which not only guarantees access (cataloguing, discovery, aggregation, navigation) and storage/archiving, but also maximises data sharing, integration and analysis. This can be achieved through cloud-based infrastructures which promote the principles of open accessibility and share standards for data sharing.
- **Algorithms and analytics**: Data analytics can be defined as the processing of analysing data to provide meaningful insights and information. The process of extraction of relevant information can be automated into processes and algorithms that work over raw data for human consumption. The automated techniques for aggregating large volumes of data, detecting patterns, identifying trends and determining relationships include the adoption of Artificial Intelligence and Machine Learning algorithms.
- **Insights and applications**: Data needs to be combined, processed and analysed to be transformed into information and ultimately actionable knowledge. End users and stakeholders must be able to understand and apply the information which is provided to them. This implies that information must be applicable, trustworthy, easy to access and simple to comprehend. In order to guarantee this, it is imperative that there is a common thread linking data producers, data managers, infrastructure experts, algorithm developers, application providers to end users and stakeholders.
- In parallel to the concepts elicited by UN Environment for a digital ecosystem, a set of concise and measurable principles have been designed to guide and improve the Findability, Accessibility, Interoperability, and Reusability of digital assets. The FAIR guiding principles for scientific data management and stewardship (Wilkinson et al., 2016) can be considered as a conduit leading to knowledge discovery and innovation, and to subsequent data and knowledge integration and reuse by the community after the data publication process.
- Building on these principles, the Secretariat on Group on Earth Observations (GEO) and the GEO Blue Planet initiative, are working on developing an ocean "Knowledge Hub", an open platform aimed at empowering global experts where co-design, co-production & full reproducibility are key.
- This is particularly relevant for countries and their National Statistics Offices engaged in Ocean Accounting (and monitoring of the Sustainable Development Goals indicators) as it will provide a platform where they can independently access data, algorithms, methodologies to produce the necessary information and actionable knowledge.

4.2.2 Earth observation data

- Earth observations can be defined as the union of diverse data sources, including from satellite, airborne, in-situ platforms, and citizen observatories, which when integrated together, provide a robust basis for understanding the past and present conditions of Earth systems, as well as the interplay between them.[1] It is therefore the gathering of Earth's physical, chemical, and biological information from a range of different sources required for improved monitoring and forecasting.

> [1] GEO Strategic Plan 2016-2025: Implementing GEOSS: https://www.earthobservations.org/documents/GEO_Strategic_Plan_2016_2025_Implementing_GEOSS_Reference_Document.pdf

- Earth Observation data can make a substantial contribution in supporting progress towards many of the Sustainable Development Goals (SDG), including those that are more socio-economic in nature (Andries, et al., 2018). In addition, there is also potential to develop indicators outside the established set of SDG indicators that may be more amenable to the use of EO-derived data, including Ocean Accounting.
- The use of international (global) space-based earth observations, combined with *in-situ* and modelling datasets, is key for achieving a solid and reproducible Ocean Accounting framework. This is even more evident as we must consider the transboundary nature of ocean related targets and indicators, specifically for the monitoring and reporting of sea areas which are beyond national (agreed or not) national jurisdiction (i.e. EEZ waters). It is imperative to have a framework, combining space-based Earth Observations together with modelling and *in-situ* datasets, providing global, regional, and national geospatial ocean products.
- The notion of national data is limited when applied to the ocean and there are a number of "global vs national" issues to be clarified, such as: (1) Who is responsible for the reporting and monitoring in areas beyond national jurisdiction (recognised EEZ's)?; (2) Who should contribute on providing an observational and measurement methodology for indicators which ensures the highest level of consistency and comparability, and; (3) What is the framework for developing transboundary ocean related SDG indicator products at global, regional, national and transboundary level?
- In this context, ocean remote sensing data is invaluable as it provides a consistent, synoptic perspective that can be leveraged in a cost-effective manner by end-users in developing as well as developed nations. Satellite sensors provide insight on physical, biological, biogeochemical, geological, and social related ocean parameters at different spatial resolutions and temporal scales (hourly/daily to multi-annual). They provide rapid, repeated and long-term synoptic observations that inform and complement (in conjunction with *in situ* measures and modelling/data assimilation activities) a nested global to basin-scale to regional to local ocean observing framework. This represents the end-to-end value chain for ocean observations, going from observations → data → products → information → knowledge for users and the attendant socio-economic benefits.
- Data collected at national level are of critical relevance for global and regional assessments. They feed analyses and modelling of regional seas while providing a validation instrument for regional and global datasets. It is important within this context to highlight that there is currently no clear framework defining: a) who should (can) contribute on providing an integrated observational and measurement methodology; b) how global and regional products can feed into national monitoring and reporting processes, and; c) who should routinely analyse, monitor and report on this indicator at global and regional level.
- Cooperation, at global to local scales and across different sectors, is crucial to achieve long-term sustainable use of our ocean resources. Regional Seas Programmes, Agreements and Conventions can be key to the sustainability of regional coastal and marine ecosystems as they provide a governance and technical/scientific mechanism for regional cooperation and coordination, aimed at advancing national and transboundary issues.
- What is the relationship between global, regional and national products and how can we ensure that the data required for Ocean Accounting purposes is freely available, consistent, comparable and spatially comprehensive? At the regional level, we could envisage a set of "packages" of products that identify (or approximate) physical or ecological base values or critical thresholds (if known), with a well-defined pathway for their delivery. These regional "actors" can thereafter work with Member States to improve the uptake of Earth Observation data (and related derived products) to be used for monitoring and reporting at national level.
- Ensuring the sustainable development and responsible conservation of our oceans requires working across national jurisdictions and open sea areas. Global Earth Observation data are fundamental resources that provide physical, biological, chemical, geological and social information on the ocean at different spatial resolutions and temporal scales.

- All data collected, created and curated by Earth observation entities, organisations and programmes is of critical importance. The following three are particularly noteworthy as they cater for the majority of the ocean satellite remote sensing, in-situ and modelling observational datasets and resources:
- Committee on Earth Observation Satellites (CEOS): made up of 55 space agencies from all around the world, exists to ensure the international coordination of satellite Earth observation programs and promotes data exchange to make satellite data available and beneficial to the world. These satellite observations are critical for ocean, coastal and land environmental monitoring, meteorology, disaster response, agriculture and other applications. CEOS organizations currently operate 112 satellites. These satellites and their related systems operate simultaneously and serve both interdisciplinary and international activities; therefore, international discussion and cooperation are critical to their success.
- Global Ocean Observing System (GOOS): A sustained collaborative system of ocean observations, encompassing in situ networks, UN agencies and individual scientists organized around a series of components undertaking requirements assessment, observing implementation and innovation.
- OceanView: Fostering the development and improvement of operational ocean analysis and forecasting systems worldwide, OceanView defines, monitors and promotes actions aimed at coordinating and integrating research associated with multi-scale and multi-disciplinary ocean analysis and forecasting systems.
- The close cooperation and collaboration with these entities and programmes is key when it comes to the definition of the Earth observation data requirements and needs for Ocean Accounting. Within this context, an initiative like GEO Blue Planet can provide the link between data producers, data managers, infrastructure experts, algorithm developers, application providers and ultimately end users/stakeholders.

4.2.3 “Essential” Ocean and Ecosystem Variables

- One of the recommendations of the OceanObs’09 conference was for international integration and coordination of interdisciplinary ocean observations under a unique and common framework. The Framework on Ocean Observing (FOO, 2012) was implemented under the auspices of the Intergovernmental Oceanographic Commission (IOC) of UNESCO and is coordinated by the Global Ocean Observing System (GOOS). It seeks to meet the need of delivering ocean data to support governance, management, science and other ocean uses. It proposes the coordination and integration of routine and sustained observations of physical, biogeochemical, geological and biological essential ocean variables, or EOVs (**Table 30**). The EOVs are closely linked to the Essential Climate Variables (ECVs) (Bojinski et al., 2014) which define the observations needed to understand and track the status and trends in climate variability.
- In parallel, the Group on Earth Observations Biodiversity Observation Network (GEO BON) has developed a framework for a set of Essential Biodiversity Variables (EBVs) (**Table 31**) for use in monitoring programs to understand patterns and changes in Earth's biodiversity (Pereira et al., 2013; Navarro et al., 2018). Within GEO BON, the Marine Biodiversity Observation Network (MBON) frames the EBVs concept for the marine realm (Muller-Karger et al., 2018).
- The ecosystem Essential Ocean Variables (eEOVs) include a set of observable ecological quantities which contribute to the assessment of the ocean ecosystem (Miloslavich et al., 2018). When assessing the condition of the marine ecosystem for the Southern Ocean Observing System, A.J. Constable et al. (2016) identified nine general ecosystem properties to be monitored. These belong to three main areas as follows: *(1)* Spatial arrangements of taxa: habitat, diversity, spatial distribution of organisms; (2) Food-web structure and function: primary production, ecosystem structure, production, energy transfer, and; *(3)* Human pressures: regional and global.
- Constable et al., (2016) used nine criteria for assessing the utility and feasibility of the candidate EOVs based on the following concepts: *(1)* Signal change in ecosystem properties; *(2)* Contribution to developing and/or applying models investigating change and attribution; *(3)* Understanding for policy-makers and the public; *(4)* Alignment with other eEOVs; *(5)* Ability to be connected to historical datasets (time-series); *(6)* Potential to be adapted through time; *(7)* Can be sampled at space and time scales appropriate to the task; *(8)* Sufficiently high signal-to-noise ratio, and; *(9)* Potential for adaptive sampling.
- These multidisciplinary and transdisciplinary efforts categorize specific ocean parameters to be monitored on a continuous basis for addressing the challenge of evaluating the status of our oceans, identify key

processes and ultimately determine the sustainability of the ecosystem as a whole, in a synergistic way. Muller-Karger et al. (2018) analyses these efforts and provides a synoptic view for linking the GOOS led effort on EOV and eEOV to the GEO BON EBV proposal. These concepts and criteria are also relevant when evaluating the typology of data sources needed for ocean accounting and evaluating the availability of data at regional and global level. Below are two tables outlining the parameters currently included as EOVs and EBVs.

Table 30. Essential Ocean Variables. Links are to EOV Fact Sheets.

Physics	Biogeochemistry	Biology and Ecosystems
Sea state	Oxygen	Phytoplankton biomass and diversity
Ocean surface stress	Nutrients	Zooplankton biomass and diversity
Sea ice	Inorganic carbon	Fish abundance and distribution
Sea surface height	Transient tracers	Marine turtles, birds, mammal abundance and distribution
Sea surface temperature	Particulate matter	Hard coral cover and composition
Subsurface temperature	Nitrous oxide	Seagrass cover and composition
Surface currents	Stable carbon isotopes	Macroalgal canopy cover and composition
Subsurface currents	Dissolved organic carbon	Mangrove cover and composition
Sea surface salinity	-	Microbe biomass and diversity (*emerging)
Subsurface salinity	-	Invertebrate abundance and distribution (*emerging)
Ocean surface heat flux	-	-
Cross-disciplinary		
Ocean colour	Ocean Sound	-

Table 31. Essential Biodiversity Variables

EBV class	EBV Candidate	Description and notes
Genetic composition	Co-ancestry	
	Allelic diversity	
	Population genetic differentiation	
	Breed and variety diversity	
Species populations	Species distribution	
	Population abundance	
	Population structure by age/size class	
Species traits	Phenology	
	Morphology	
	Reproduction	
	Physiology	
	Movement	
Community composition	Taxonomic diversity	
	Species interactions	
Ecosystem function	Net primary productivity	
	Secondary productivity	
	Nutrient retention	
	Disturbance regime	

Ecosystem Structure	Habitat structure	
	Ecosystem extent and fragmentation	
	Ecosystem composition by functional type	

4.2.4 Fisheries data (national)

- Large, industrial, fisheries and smaller scale fisheries are two very different areas with differing international data collection requirements and levels of interest domestically. Extensive data is held on industrial fisheries, including comprehensive stock assessments for many species. Industrial fisheries face transboundary issues where the fish move freely between EEZs and therefore inclusion in Ocean Accounts needs to be carefully thought through. Measurement of small-scale fisheries, reefs and associated ecosystems is challenging. Within the Pacific only a handful of countries have comprehensive vessel registries, with most not collecting comprehensive catch data. Often best available data on small scale and domestic coastal fisheries are from the Household Income and Expenditure Surveys (HIES) which now has a standard fisheries module. As much of the small scale and coastal catches are subsistence or for local sale these do not appear in normal market surveys, export data or structured buying records of businesses. What data exists for small scale fisheries tends to be disparate and held across multiple institutions and access can be hard, or impossible, to get. As a result, measuring year-on-year changes will be challenging and attributing changes more so.
- Recent research suggest species abundance (fish stocks) can be estimated from data-poor fish stock assessments, where a review of methods suggests a Bayesian hierarchical framework is the most feasible approach [1]. Further research suggests developing relative abundance indices based on spatially detailed fisher catch and effort data [2].
- Current fisheries accounting approaches have recognized the differing needs of commercial and small-scale fisheries from a data collection and account maintenance perspective. Nationally-based efforts to develop fisheries accounts have performed pilot studies to focus on either commercial or small-scale fisheries, directed either by a government or international entity (non-profit, NGO, UN partnerships). Accounting pilot studies on commercial fisheries include:
    - Natural Captial Accounting and Valuation of Ecosystem Services (NCAVES) project in China, relating fishing intensity to the loss of ecosystem services and net effects on marine GDP in 2018
    - Phillipines use of a satellite accounting approach determined in 2018 the fishing sector contributed the largest share of the Philippine ocean economy at 29% [3] which is instrumental in guiding the monitoring and assessment of ocean-related economic targets set in the 2017-2022 Philippine Development Plan (PDP).
    - Canada's Department of Fisheries and Oceans (DFO) collaboration with Statistics Canada to apply to the ocean accounts framework in a pilot project to harmonize key ocean-related data, include commerical fisheries contribution to marine GDP.
- Small-Scale Fisheries Account Development examples include:
    - Fiji Bureau of Statistics compilation and annual publication of subsistence, informal, and small-scale aquaculture GVA as part of its GDP compilation.
    - Environmental Defense Fund's (EDF) work on community-level fisheries in Baja California, Mexico since 2015 to create satellite fishery accounts at remote fishing villages.
    - International Institute for Environment and Development (IIED) development of a toolkit for small scale fisheries in Costa Rica in 2019 which provides the framework to mainstream values of small scale fisheries in national accounts.

[1] Chrysafi, A., & Kuparinen, A. (2016). Assessing abundance of populations with limited data: Lessons learned from data-poor fisheries stock assessment. *Environmental Reviews*, *24*(1), 25-38.
[2] Campbell, R. A. (2016). A new spatial framework incorporating uncertain stock and fleet dynamics for estimating fish abundance. *Fish and Fisheries*, *17*(1), 56-77.
[3] Ocean-based industries in the 2009 study included fishery and forestry; mining and quarrying; construction; manufacturing; transport, communication, and storage; trade finance; and services

4.2.5 Fisheries data (intergovernmental)

- Key sources and initiatives: Coordinating Working Party on Fishery Statistics (CWP); FISHCODE STF – Strategy for Improving Information on Status and Trends of Capture Fisheries; Aquatic Sciences and Fisheries Abstracts (ASFA); Fisheries and Resources Monitoring System (FIRMS); Fisheries Global Information System (FIGIS); FAO FishFinder, the Species Identification and Data Programme; GLOBEFISH – Analysis and information on world fish trade; Global Record of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels; FishStatJ – The FAO Fisheries and Aquaculture Department uses a software for fishery statistical time series. In November 2017 a new version of FishStatJ was released. This version can access the information on "Fisheries Commodities Production and Trade 1976-2015."; Global Record of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels; The 2017 Global Record on Voluntary Guidelines for Catch Documentation Schemes
- There are a number of international instruments meant to regulate fisheries and prevent or at least deter Illegal, Unreported and Unregulated Fishing or IUU fishing at the global, regional and national levels. At the international level, these standards are found in: 1) The 1982 United Nations Convention on the Law of the Sea (UNCLOS/ LOSC); The 1993 FAO Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (the 1993 Compliance Agreement; 3) The 1995 UN fish Stocks Agreement; The 1995 Code of Conduct for Responsible Fisheries; The 2001 International Plan of Action to Prevent, Deter, and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU); 6) The 2005 Rome Declaration on Illegal, Unreported and Unregulated Fishing; The 2009 Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing, 31/12/2016 FAO, Revised edition; The 2014 Voluntary Guidelines for Flag State Performance; and FAO Voluntary Guidelines for Catch Documentation Schemes. 7) Regional Fishing Management Organizations (RFMOs) are pivotal in facilitating intergovernmental cooperation in high-seas areas, in managing and monitoring major deep-sea fisheries.

4.2.6 Socio-Economic conditions

- In addition to environmental (state of the ocean) and fisheries related ecosystem datasets, Andries et. al. (2018) have demonstrated the increasing opportunity of Earth Observation data to complement or even replace traditional ground-based methods of collecting environmental and socio-economic data. Examples include, indicators of economic growth (Henderson, et al., 2011), socio-economic activities (Chen & Nordhaus, 2011), urbanisation impacts on the environment (Ma et al., 2012), daytime and night-time fishing activities (Waluda et al, 2004; Straka et al., 2015).
- One important element related to economic activity is maritime transport and associated port operations. Over 80 % of world merchandise trade by volume is being carried by sea and maritime transport remains the backbone supporting international trade. Maritime traffic is monitored at national and regional level through an International Maritime Organisation (IMO) regulation which requires Automated Identification System (AIS) to be fitted aboard all ships of 300 gross tonnage and upwards engaged on international voyages, cargo ships of 500 gross tonnage and upwards not engaged on international voyages and all passenger ships irrespective of size. The regulation requires that the exchange of AIS shall include the ship's identity, type, position, course, speed, navigational status and other safety-related information - automatically to appropriately equipped shore stations, other ships and aircraft. This data is used to monitor and track vessels globally as AIS signals can be detected by both shore stations and by satellite.

- Vessels engaged in fisheries activities also need to report their locations. The vessel monitoring system (VMS) is a satellite-based monitoring system which at regular intervals provides data to the fisheries authorities on the location, course and speed of vessels. AIS and VMS real-time, historical and traffic density data, are key elements for evaluating the maritime transport component within an Ocean Accounting framework. Further to this, the environmental signature of the maritime transport community on the ocean ecosystem can be monitored through Earth observation. One such example is the monitoring and reporting of oil spills from vessels.

4.2.7 Data platforms

- Many countries still have problems when accessing data (IAEA, 2014). Data can be scarce, or not available in a timely fashion, or too complex to discover and access.
- However, the volume of data available is constantly increasing. For example, the daily volume of data from the EU's Copernicus Earth Observation programme Sentinel satellites is estimated to be approximately 20 Terabytes per day (Esch, et al., 2018).
- The term "Big data" is commonly used to describe the sheer amount of data collected by sensors, however data can be big in different ways: data volume, variety of form, velocity of processing, veracity of uncertainty (Lynch, 2008). Due to these considerable increases, the challenge has been for the last years to develop solutions which "bring the user to the data instead of the data to the user". This is made possible by technological advances in cloud technologies, the development of data cube technologies, the availability of Analysis Ready Datasets (ARD) and ultimately the development of web-based platforms providing access to these services. As part of this effort, the Group of Earth Observation is developing a concept of "Knowledge Hub" which applies a zero download model and ultimately empowers global experts to use Earth Observation data (satellite remote sensing, in-situ and modelling) to create reusable and shareable knowledge.
- Requirements for spatial resolutions and temporal sampling vary for different data types. For example, some ecosystem geospatial parameters do not need to be measured every year due to their multi-annual longevity, while others have seasonal and inter-annual variation related to their processes and hence may need to be estimated on a monthly or annual basis. There are multiple platforms nowadays available where to gather Earth Observation datasets and information. While it is not the objective of this Technical Guidance document to provide a fully comprehensive list of all available data platforms, this section will provide a number of references for use.
- The scores of different data platforms vary from online search and download portals to processing and analytical tools. Data availability ranges from in-situ point measurements to raster products based on satellite datasets, from local to global spatial coverage and from real-time to historical climatologies. In addition, datasets offered by platforms vary from general applications down to specific local applications.
- Pendleton et al. (2019) argue that although many ocean data platforms exist, we lack an understanding and regular monitoring of the biological and human dimensions of the ocean. Many habitats, including the deep sea, ocean trenches, ice-bound waters, methane seeps, and even coral reefs remain poorly studied at the global scale. Costello et al. (2010) show that geographic gaps in biodiversity data are particularly acute for many parts of the global ocean including coastal areas of the Indian Ocean, the southern and eastern Mediterranean Sea, polar seas, and much of the South American coastal ocean.
- According to Arzberger *et al.* (2004), Chavan and Ingwersen (2009), Costello (2009), Kim and Zhang (2015) and Ferguson *et al.* (2014) online platforms are often discipline-specific or application specific, creating barriers to discovery and integration. In addition, in many cases data are easily dissociated from the people who helped create and curate them, rendering communication between users and producers challenging.
- As previously mentioned, many different data platforms exist, each providing access to different types and levels of Earth observation data. We are however observing an important shift whereby users do not need to shift and download large volumes of data anymore for processing and provide access to the data and to the analytical algorithms directly on the cloud. This can potentially decrease the barriers for users in both developed and developing countries.
- Examples of online platforms include Geo-Wiki, Google Earth Engine (GEE), the different Copernicus Data Information and Access Services (DIAS), Earth Server2, Digital Earth Australia and many more.

- There is nevertheless to date no established optimal data platform implementation and best practice for applications in the ocean and coastal domain. For Ocean Accounting purposes this is even more true as there is the need to integrate distinct geospatial observations from diverse ecosystem domains, extrapolate this observational knowledge to include the full 3-d ocean (i.e. also including below the sea surface) and combine with socio-economic information, all under the appropriate statistical framework.
- The 'Geo-Wiki' and the 'Openforis Collect Earth' initiatives are examples of platforms which use earth observation and citizen science to conduct research and provide data, tools and services to perform fast, accurate and cost-effective assessments. They however have thus far only been used for land-based applications.
- Some areas where online data platforms have been used to support the development of monitoring and management applications in the ocean and coastal domain have been for mangrove monitoring and conservation and coral reef mapping.
- While it is not the objective of this Guidance document to provide a comprehensive list of available data platforms, **Appendix 6.1** provides many references. As well, **Appendix 6.1** contains a summary of ESCAP's Global Ocean Data Inventory, which is available online[4], and is classified according to the components of the ocean accounts framework. Efforts are ongoing to link with work with IOC-UNESCO's ODISCat.

ⓘ [4] Available as a formatted report and concise table (links embedded).

[Figure on Data Platforms under development]

4.2.8 Modelling

- In the past, measured data and modelled data relevant to the ocean are often used for different purposes and by different communities. However, an emerging approach is to consider measured datasets and modelled data within the same information infrastructure. That is, models can fill in gaps by estimating data from what has been observed in other locations or periods. Similarly, measured data can be used as additional input to models. Together, they can support the development of future scenarios.
- The SEEA-EEA Expert Forum (UNSD 2015) suggested a review of ecosystem services models with the intent of better understanding opportunities for applying them for official statistics. A review was initiated, but not completed (Bordt, Jackson and Ivanov, 2015). The SEEA-EEA Technical Recommendations (United Nations, 2017) include a brief review of some ecosystem services-related biophysical models.
- The term "modelling" for the purposes of this paper is intended to include any quantitative or qualitative approach used in the absence of measured data. This would include estimation, interpolation, projection and scenario approaches.
- Other than estimating or projecting the provision of ecosystem services, models have also been developed to estimate fish stock dynamics, economic production/consumption, ocean and climate dynamics and potential impacts from natural disasters.
- As with the ecosystem services-related models reviewed, it is expected that other models and the accounting approach could be mutually reinforcing: (a) estimating accounts data where data are unavailable and (b) using accounts data and classifications in models. Projecting future conditions are generally out of the scope of the SEEA itself, but the calculation of asset values depends on assumptions about the future stream of services. It has been suggested that to accomplish this, a baseline future scenario would be required. For example, estimating a future stream of services based on expected changes in the extent and condition of the stock. **Table 32** and **Figure 18** illustrate potential linkages between modelling approaches and Ocean Accounts.
- Better linking accounts with models is one approach to linking individual models together. For example, models focussing on stocks could be linked to models on production and consumption if concepts and classifications were aligned.
- Options to be explored include (a) using modelling approaches to estimate missing data in accounts, (b) using accounts to provide data to models, (c) using scenario approaches to estimate future conditions, and (d) other projection approaches.

Table 32. Illustrative contributions of modelling to Ocean Accounts. *Source: Bordt et al, 2015. Note: Numbers refer to **Figure 18**. The number zero (0) refers to components not systematically treated in SEEA-EEA.

Step	Accounts covered	Possible contributions of modelling*
Determine the purpose of the account	All (prioritization of accounts and approaches)	[0] Impact screening (Currently suggest applying Diagnostic Tool) [0] Scenario specification (general futures modelling)
Delineate ecosystem assets	Extent	[3] Delineating "optimal service-providing units" (e.g., delineation of socio-ecological landscapes…) [3] Hydrological, ocean dynamics modelling may be required to delineate freshwater, coastal and marine spatial units.
Compile Ecosystem Condition Account	Condition (with linkages to Water, Carbon, Biodiversity Accounts)	[1] Estimating unmeasured conditions based on known biophysical characteristics (e.g., estimating phosphorous absorption of a wetland based on its size, type and flow) [1] Estimating unmeasured conditions from known conditions (e.g., estimating soil quality based on quality of nearby sites) [4] Estimating unmeasured conditions from known "pressures" (e.g., effluents, emissions, land use intensity, fertilizer & pesticide application…) [5] Aggregating conditions over indicators and structural characteristics (e.g., land, vegetation, water, biodiversity, carbon, air…) may require statistical modelling (e.g., principal component analysis), models to determine thresholds… [6] Producing specific estimates from water, carbon and biodiversity modelling (water quality, water supply, carbon balance, primary productivity, habitat suitability, habitat and species conservation status)
Measure ecosystem services in physical terms	Physical Services Supply and Use	[2] Estimating services supply from extent and conditions (ecological production functions, functions transfer) [7] Linking ecosystem services to specific ecosystem assets [8] Allocating services to beneficiaries (local, national and global) [9] Estimating contribution of ecosystems to benefits (economic production functions)
Conduct monetary valuation of services	Monetary Supply and Use	[10] Estimating unknown prices from known prices (benefits transfer, meta-analysis…)

	Monetary Ecosystem Asset	[2] Estimating future flows of services (ecological production functions) [11] Estimating future conditions/capacity (scenario analysis, socio-economic modelling, global dynamics modelling [e.g., climate change, ocean acidification, habitat loss], ecological production functions)
Link to standard economic accounts	Integrated Accounts: Extended Input-Output Table, Sequence of Sector Accounts, Balance Sheets	[12] I-O modelling (balancing supply/use) [13] Estimating degradation-adjusted aggregates (GDP, national income, national savings)

Figure 18 Components of SEEA-EEA amenable to modelling/estimation

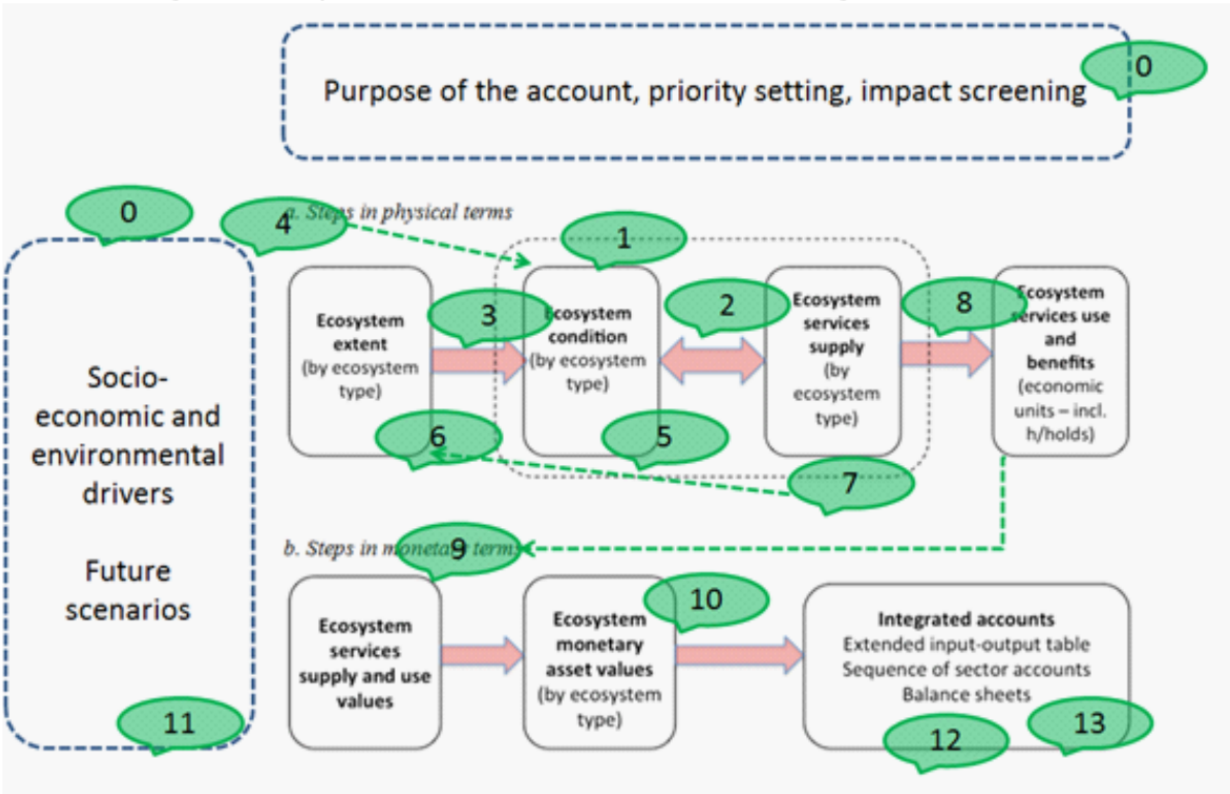


Figure 18. Components of SEEA-EEA amenable to modelling/estimation

4.2.9 Core ocean statistics

- The previous sections describe and use a range of data at various levels. In this section, we sort through these and suggest a set of 30 Core Ocean Statistics that are relevant to most countries and most countries should be able to collect them.

- Each data collection has its unique specifications of how the data are collected, aggregated and presented. One principle of the core set is that the compiler of ocean accounts should be able to consult various agencies and academic experts and ask if data are available for a certain statistic. The descriptions need to be sufficiently precise to communicate what is required without being so precise that it is never coincides with what is available. We apply the terminology for “variables”, “indicators” and “index” of the SEEA[5] in terms of levels of aggregation:
    - *Variables are any quantitative measure reflecting a phenomenon of interest*. Variables may measure individual characteristics and are often direct measures, such as temperature or number of individuals of a species;
    - *Indicators are variables with a normative interpretation associated…with a view to informing policy and decisions*. Indicators are often the results of comparison with a reference condition, such as temperature above seasonal average, or number of individuals in a species compared to 10 years ago;
    - *An index is a (thematically) aggregated indicator, which represents relatively broad aspects of the studied system in a single number*. Temperature is combined with other data on timing to create indices of growing season length. Populations of several species may be combined into a biodiversity index.

ⓘ [5] Definitions in italics adapted from SEEA Ecosystems revision Discussion Paper 2.3, “Proposed typology of condition variables for ecosystem accounting and criteria for selection of condition variables”.

- For the purposed of this guidance, “statistics” may be any variable, indicator or index or information about them, such as mean, median, maximum, etc. Another consideration is that indicator frameworks may be referring to variables, indicators, and indices without distinguishing among them. The lists of core ocean statistics begin with a general description of 30 kinds of statistics that should be included in a national core set. These are neither variables, indicators, nor indices, but general topics that should be considered. We then provide specifications for more detailed statistics for specific ocean ecosystem types. This description is still rather generic in that for any statistic, there may be a choice of several measurements and analytical methods to produce them. Such details are beyond the scope of this guidance and would not be globally applicable.
- Given the breadth of the ocean accounts, a discussion of how a statistic fits would help searching for it and fitting it into the appropriate accounts. Since this section introduces new concepts, the discussion in **Appendix 6.9** provides an explanation of how some “stressors” can be treated in the ocean accounts. Table 30x presents a list of “core ocean statistics” which should form the basis of an ocean account. These statistics are organized by Ecosystem Condition (Scientific-generated data and Resources) and Ecosystem Services (Regulation, Provisioning, Cultural, and Governance). These statistics can be sourced from both public and private sectors and the organization and availability of these data will depend on national ecosystem accounting practices. The statistics provided in Table 30x here are only a baseline suggestion and will require a feedback loop of development in early stages of implementation, especially when considering the context within a specific ecosystem type To provide a starting basis for ocean account building, ET-specific tables have been created in **Appendix 6.1** which inform on the variables most informative for each ecosystem type. These variables have been sourced from the primary literature and identified as informative to Ecosystem Condition and Services categories.
- Locations in Technical Guidance Manual which can be referenced when defining Economic, Social, Governance, and Biophysical Indicators part of Table 30x core statistics.
    - **Economic:** Potential examples of economic statistics includes:
        - **Section 2.3.1 Defining Environmental Assets**
        - **Section 2.3.5 Monetary asset accounts**
        - **Figure 3: Flows to the economy (supply/use of energy, water, materials)**
        - **Classification of Ocean Assets**
        - **Section 2.9 Ocean Wealth** (SEEA and SNA balance sheet)
        - **Table 14 ISIC Codes**

- **Social:** Potential examples of social statistics:
    - **Classification of Ocean Ecosystem Services**
    - **Table 8 Provisioning, Regulating, and Cultural**
    - **Table 9 Ecosystem Services**
    - Fisheries Income (Split between commercial/artisanal)
    - Sustainable Fishing/Harvesting Practices
    - Tourism Income
    - **Measures of Economic Activity**
- **Governance:** Potential examples of governance statistics
    - **Monetary flow (supply and use accounts)**
    - **Table 9: Government expenditures on ocean management and protection/enforcement. Pollutant loading.**
    - **Definition of governance**
    - **Table 16-18: Governance Tables**
    - **Assessing Governance**
    - **Appendix 6.4 Potential FDES topics and statistics applicable to Ocean Accounts**
- **Biophysical:** Statistics which inform on biophysical processes can be sourced from already existing publicly available datasets (see **Data Platforms**), active government-funded research, or private research endeavoured for the specific purpose of ocean account building.

- It is important to note the biophysical statistics listed in Table 30x are a general guide for all marine ecosystem types. The relative informative power of these biophysical statistics will change depending on the ecosystem type (ET; see **Classification of Ocean Ecosystem Services**). To better inform the user on which statistics to prioritize for a given ET (Coral Reefs, Mangroves, Kelp Forests, Estuaries and Salt Marshes, Sediment, and Open Ocean) within the defined BSU (basic spatial unit; see **the spatial data infrastructure for Ocean Accounts**), see **Appendix 6.10**: Core Ocean Statistics for Key Ecosystem Types.

Table 30x. Core Ocean Statistics (in progress)

Ocean Assets	Link to framework
Condition	
Biodiversity	2.3.4
Ecosystem Fitness	2.3.4
Biogeochemical Cycling	2.3.3
Physiochemical Status	2.3.4
Greenhouse Gas Retention	2.3.4
Stock	
Ecosystem Extent	2.3.4

Stock of Natural Aquatic Resources (Vertebrates)	2.3.4, 2.9.2
Stock of Natural Aquatic Resources (Invertebrates)	2.3.4, 2.9.2
Stock of Cultivated Aquatic Resources (Vertebrates)	2.3.4
Stock of Cultivated Aquatic Resources (Invertebrates)	2.3.4
Stock of Abiotic Resources	2.3.4
Ocean Services (Flows to the Economy)	
Regulating	
Greenhouse Gas Sequestration	2.4.4
Coastal Protection	2.4
Erosion Control	2.4
Water Purification	2.4
Nutrient Cycling	2.4
Waste Remediation	2.4
Pollutant Remediation	2.4

4.3 Policy and governance use cases for Ocean Accounts

- Ocean Accounts are one of a range of different information products that can be used to support policy-making and other government decision-making related to oceans. These can be distinguished from one other in terms of an "information pyramid" that differentiates between the level of information presented, and by the functions an information product supports in government decision-making (see **Figure 19** below). The pyramid classifies information products into four groups in a hierarchical structure with each layer feeding the layers above. Data and statistics are the foundation of the pyramid and support the operation of an ocean accounting system. Indicators are produced from the accounts, which can be aggregated to produce key indicators. Indicators can be source both directly from data and statistics, and from the accounts.

Figure 19 Relationship between Ocean Accounts and other information products

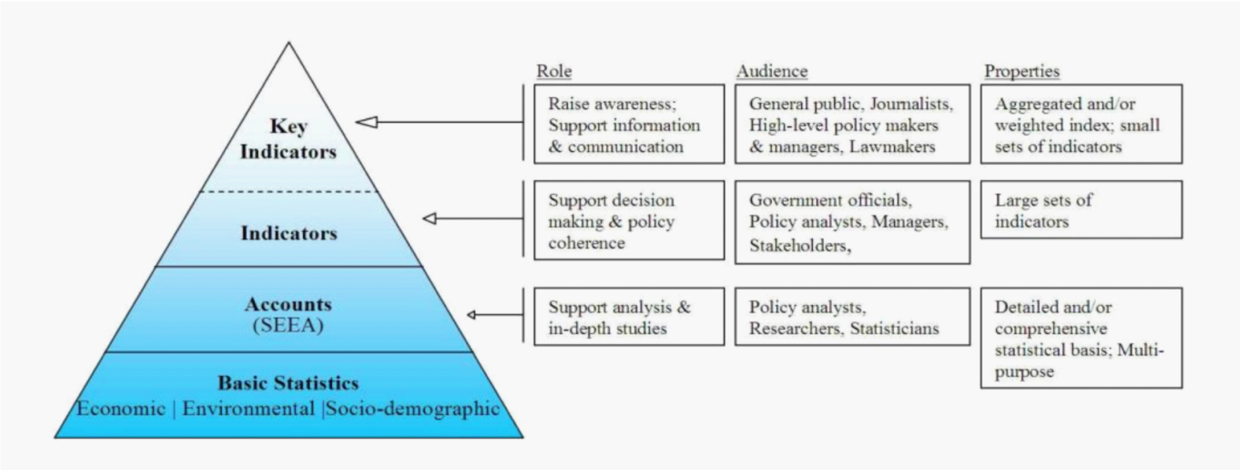


Figure 19 Relationship between Ocean Accounts and other information products.

- Within a comprehensive information system for government decision-making, Ocean Accounts (and all accounts) provide an intermediate structure that connects higher level information (indicators) with lower level information (basic data and statistics) in a coherent framework. Consequently, they support analysis and decision-making in a wide variety of policy and governance use cases. A non-exhaustive selection of these use cases is explained further below, organised into the following categories:
  - *Strategic and planning decisions:* including those associated with marine spatial planning, and formulation of strategic development plans for the ocean economy.
  - *Regulatory decisions:* including granting of permits and licenses for marine activities, in accordance with relevant spatial and development plans or other policy objectives.
  - *Operational and management decisions:* including integrated coastal zone management, ecosystem-based management, management of marine protected areas, other forms of local marine area-based management, and disaster risk response.
  - *Finance and investment decisions:* including fiscal policies and programmatic investment related to oceans, including funding for administrative capacity concerning oceans.
  - *Technical advice and reporting:* including cost-benefit assessment, environmental impact assessments, progress reporting against agreed commitments, and supporting the delivery of decision-making in the above categories.

4.3.1 Strategic and planning decisions

- Decision-making about the ocean is increasingly informed by a range of laws, policies, and processes designed to pursue defined strategic objectives, and/or plan use of ocean space in an integrated manner. Prevalent features of ocean policy and governance in this context include:
- *Strategic development plans for the ocean economy*, including the proliferating range of national "Blue Economy", "Ocean Economy" and "Blue Growth" plans that establish multi-sectoral development objectives and targets aligned with diverse guiding principles. A regionally representative list of examples includes the European Union's Blue Growth Strategy, South Africa's Operation Phakisa Oceans Economy strategy, Fiji's National Ocean Policy, and Chapter 41 of China's 13th Five-Year Plan for Economic and Social Development focusing on "widening space" for the Blue Economy.
- *Marine spatial planning (MSP):* is commonly defined as a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and

social objectives that are usually specified through a political process. Diverse MSP approaches are implemented by at least 70 countries across all major regions.

- Ocean Accounts can perform several support functions for strategic and planning decisions that may justify a decision to invest effort and resources to compile them. By virtue of their holistic and integrated structure, Ocean Accounts can be used as a basis for analysing the economic relevance of the ocean's environmental assets, the environmental implications of ocean-based economic activity, and wide a range of other relationships that impact on the ability of countries to achieve sustainable development. This analysis supports the identification and evaluation of policy response options, in terms of their impacts on assets (environmental, social, economic) that underpin development, and on the flows of services and benefits from these assets.
- More specifically, the Ocean Accounts Framework provides a basis for compiling three broad domains of aggregate indicators that are directly relevant to **performance monitoring of ocean development strategy**:
    - *Ocean product*, focusing on the economic outputs of human activity regarding the ocean, with monetary components aggregating to ocean Gross Domestic Product or net domestic product (NDP),
    - *Benefits received by nationals from the ocean*, including physical measures of ecosystem services, and monetary measures of ocean income that can be aggregated to net national income (NNI) and gross national income (GNI). Income measures can be (and benefit from being) disaggregated to show the importance of the ocean for different segments of the population, for example women, indigenous peoples, and other marginalised groups.
    - *Change in the ocean balance sheet*, which provide an important sustainability indicator when the balance sheet is sufficiently comprehensive including both environmental assets and other subcomponents of national wealth (e.g. SNA 2008 produced assets) recognised in the Ocean Accounts Framework.
- Ocean Accounts also provide a holistic and coherent "common set of facts" consistent with the Marine Spatial Planning (MSP) framework, which aims to understand and allocate the human use of marine areas over space and time to meet social, economic and environmental targets. As such, MSP provides a framework for relating diverse sets of data, where plans are formed through the integration and consideration of:
    - Governance data to define MSP targets.
    - Socio-economic data to define human activities and the relationships of environmental goods and services with society.
    - Environmental and biophysical data inform the context of the area in which the plan will be implemented.
- Whilst MSP is ideal for integrating diverse sets of data, there is a lack of standardised statistics or reporting structure between spatial plans at a regional or international scale. Frameworks for Socio-economic statistics and reporting exist and are widely applied (e.g. SNA) although are mostly limited to the national level and are heavily aggregated. Environmental and biophysical data are collected in the context of addressing discrete issues in space and time and are thus often opportunistic and incomparable.

4.3.2 Regulatory decisions

- Regulatory decisions concerning the ocean include the issuing of permits and licences to authorize otherwise prohibited marine activities—such as pollution within defined limits, extraction of resources, or the construction of infrastructure. In many countries legislation or policy requires that regulatory decisions should be made in accordance with an overarching spatial plan or set of strategies priorities, unless particular circumstances indicate otherwise.
- The information considered by regulatory decision-makers is often collected on an ad hoc basis by the individual or organisation seeking permission to undertake an activity. Proponents of activities with potential impacts on the environment are commonly required to complete and submit an:
    - Environmental Impact Assessment, in accordance with procedures that ensure that the environmental implications of decisions are taken into account before the decisions are made.[6]

- Social Impact Assessment, in accordance with equivalent procedures focusing on social issues.[7]
- Integrated risk assessment, for example those aligned with the World Bank's Environmental and Social Framework focusing on environmental and social risks and impacts, labour and working conditions, resource efficiency and pollution prevention and management, community health and safety, land acquisition, restrictions on land use and involuntary settlement, biodiversity conservation and sustainable management of living natural resources, indigenous peoples and certain traditional local communities, cultural heritage and financial intermediaries.

> [6] See e.g.: https://ec.europa.eu/environment/eia/
> [7] See e.g.: http://statedevelopment.qld.gov.au/coordinator-general/strong-and-sustainable-resource-communities/social-impact-assessment.html

- In this context all relevant stakeholders (including the general public) commonly do not have access to the best available data concerning the impacts and development implications of regulated activities. This can result in suboptimal decision-making, inefficiency, additional costs for those seeking regulatory approval, and poor public transparency.[8] Ocean Accounts can contribute to overcoming these shortcomings by providing a common, quality-controlled and standardised data reference point for regulatory decision-makers, project proponents and other interested stakeholders. Being a retrospective information system, they do not provide direct insights related to the consequences of proposed activities. However the information contained in a sufficiently comprehensive ocean account provides the data inputs needed for modelling and other prospective assessments undertaken as part of a regulatory decision-making process.

> [8] See, e.g. Independent Review of the Environment Protection and Biodiversity Conservation Act 1999 (Cwth, Australia).

4.3.3 Operational and management decisions

1. Operational and management decisions concerning the ocean can be organised into several broad domains, including those summarised in the first and second columns of the Table below. The third column summarises use cases for ocean accounts associated with each domain of operational and management decision-making.

Table X. Operational and management decisions concerning the ocean. Summaries adapted from, *inter alia*, the High Level Panel for a Sustainable Ocean Economy Blue paper: Integrated Ocean Management.

Decision-making domain	Description	Use cases for Ocean Accounts

Integrated coastal (zone) management (ICZM)	The process for managing all coastal issues in a framework integrated across biota and habitats, time and space, and levels of government. It attempts to consider and streamline cooperation among a range of stakeholders and government agencies. The overarching aim of ICZM is sustainability, while achieving the best possible outcomes for both large-scale and local-scale issues concerning society, the environment and the economy.[1]	— Holistic progress monitoring for ICZM drawing on statistics across the Ocean Accounts Framework — Data sharing and coherence between different institutions responsible for ICZM.
Ecosystem based management (EBM)	Commonly defined as management of natural resources focusing on the health, productivity and resilience of a specific ecosystem, group or ecosystems or selected natural assets and the nucleus of management. A key purpose is to recognise the full array of interactions within an ecosystem, including with humans, to drive the integration of management planning and implementation across sectoral agencies. EBM can be contrasted with historical approaches that focus on a single species, considering the cumulative impacts of different factors.	— Recording and reporting of the status of ecosystem assets and associated flows to and from the economy, in addition to relevant social and governance circumstances — Standardised integration of siloed / specialised environmental data, for example concerning different species, habitats and human interactions.

Adaptive ocean management (AOM)	Commonly defined as a systematic process for continually improving management policies and practices toward defined goals by learning from the outcomes of previous policies and practices. It recognises the inherent variability and dynamic nature of the ocean in terms of its bio-physical processes and social and economic factors, in light of scientific uncertainties. A characteristic feature is periodic reviews of and updates to management plans, in addition to adding of ad hoc opportunities for responding to unexpected events.	— Holistic tracking and reporting of change processes as in input to AOM, drawing on statistics across the Ocean Accounts Framework — Data sharing and coherence between different institutions responsible for AOM.
Area-based measures including marine protected areas (MPAs)	Involves the designation of specific operational and management paradigms to a particular space. An MPA is defined by the IUCN as a "clearly defined [marine] geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values".[2]	— Holistic tracking and reporting of environmental status within MPAs, human pressures / drivers relevant to MPA condition, and values of flows of goods and services associated with environmental assets located in MPAs. — Identification of candidate areas for protection based on diverse criteria: e.g. ecological condition, flows of goods and services, human interactions, economic values, etc. — See also supplementary comments below.
Disaster preparedness and response (DPR)	Includes a range of activities including review and updating of continency plans and programmes, investment in forecasting and early-warning systems and emergency communications, maintaining resilient critical infrastructure, training, risk mitigation, etc.[3]	— Identification and reporting of relevant risks, and impacts of disasters on social, economic and environmental phenomena within scope of the Ocean Accounts Framework. See also supplementary comments below.

Table footnotes:
[1] https://soe.environment.gov.au/theme/coasts/topic/2016/integrated-coastal-management-frameworks, https://doi.org/10.1016/0964-5691(93)90020-Y

[2] https://oceanpanel.org/sites/default/files/2020-05/BP14%20IOM%20Full%20Paper%20Final%20Web.pdf
[3] See: https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf

- **Supplementary comments regarding disaster preparedness and response:** Ocean accounting and DPR should seemingly go hand in hand. Preparedness for disasters both from a management standpoint and an economic viewpoint are essential to help maintain the stability and sustainability of a disaster-prone area, such as a coastal community or small islands. Analysis conducted by Phaup and Kirschner (2010) identify that budgeting and accounting for natural disasters oftentimes comes after the disaster. What they found was that in cases of pre-budgeting for disaster relief, there were both pros and cons. On the plus side, the policies set in place through this pre-budgeting determination will allow for a more stable and reliable method of allocating funding. Additionally, these policies can be used to provide financial incentives and opportunities to increase national savings, reduce risk exposure, and increase mitigation before disasters. Conversely, there then can be less consumption of those would-be savings.
- Ocean accounting provides a structure and approach to measuring and accounting for ecosystem services in relation to disaster risk reduction using nature-based solutions. The European Union defines nature-based solutions as those that are “inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions." There are several examples of nature-based solutions to disaster risk reduction with respect to the ocean. For instance, healthy coral reefs act as natural breakwaters that significantly reduce wave energy and mangroves provide cost-effective coastal protection services from strong wind and waves resulted from hydro-meteorological disasters such as storms, cyclones and tsunamis; they are also essential habitats for aquatic resources which help improve lives and livelihoods of coastal communities.
- Japan, New Zealand, and Turkey provide examples of how budgeting for national disasters, though the cases provided were earthquake related, primarily, can be an effective way to help recovery efforts and funding, mainly through national insurance programs. In regards to ocean accounting as a means for disaster risk tracking and response, but using what is known about the socioeconomic impact of oceans, from oil extraction, ecotourism, shipping, and other use cases, the valuation of our oceans can help determine what policy mandates are necessary to allocate funds for disaster tracking and response.
- **Supplementary comments regarding MPAs:** The largest MPAs are offshore regions that include the water column and seabed, although protections may also extend to coastal environments, such as wetlands and estuaries.[4] There are several motivations for the designation of an MPA, such as the conservation or restoration of certain ecological and cultural features that are considered significant due to their vulnerability, rarity and uniqueness. Other MPAs may be formed for the protection and conservation of natural resources for research or sustaining socio-economic activities, such as nurseries for fisheries production.[5] MPAs are managed by governments at a variety of scales (local to international), with often complex governance and legislative structures. Cutting through the minutia and bureaucracy of what the specific intent or definition of marine protected areas, at the core, conservation and management of aquatic resources are key.
- Marine Protected Areas can be considered the spatial (and temporal) management of certain human activities, to protect, conserve and restore the ecosystem goods and services, and resulting benefits to society that these areas provide. MPAs recognise the pressures and impacts imposed by certain human activities and limit their intensity and distribution. Therefore, the designation of MPAs requires an understanding of ecological, social, and cultural significance of an area, in addition to the trade-offs from managing human activities on flows of ecosystem goods and services and resulting transfer of benefits. Ecosystem-based Marine Spatial Plans are ideally positioned to designate MPAs, as a means of balancing socio-economic and environmental values towards sustainable development.
- Marine Protected Areas play crucial roles evidence of which is within scope of ocean accounting. They not only provide and transport goods and services for human well-being, but also they have inherent value beyond economics, in the form of “environmental costs sustained for the generation of natural stocks and

ecosystem service flows." A case study assessing the value of natural capital in the central Italian islands of Ventotene and S. Stefano was completed by using an energy accounting based model on biophysical and trophodynamic environments accounts. The natural capital was estimated based on the work done by the biosphere in the location of the model and used to determine the ecological value of natural capital stocks. The results of this case study provided support for policy makers and local managers to show the monetary and ecological value for developing MPAs.
- In California, work is ongoing to show the linkages between two different acts: the Marine Life Management Act, aimed at improving and developing sustainable fisheries and best management practices, and the Marine Life Protection Act to implement a network of MPAs. The research is using the principles of ocean accounting, which this document may be able to help boost their work even more, to show how adaptive management of MPAs quantifiably improved fishery health and reduced environmental impact. Additionally, they would use the information from a life history model to show how the impact of increased resilience to environmental variability, such as climate change, found in an MPA, would benefit fisheries.

4.3.4 Finance and investment decisions

- Finance and investment decisions focus on the allocation of monetary resources from the public or private sector to maximise value, where the prioritisation of such values may be economic, environmental and/or social in nature. As noted in the World Economic Forum's Ocean Finance Handbook, "Both investors and the projects that they invest in must be able to provide information on their performance, status and some means of forecasting for the future. These abilities rely on good data management—ranging from data collection to analysis and proper and secure storage. Without effective data management, it becomes nearly impossible to predict how much return on investment a project is likely to generate, and therefore what sort of investor to try to attract, or how to structure an investment proposition. It also impedes the ability for an investment project to be assessed once it is underway, to determine whether performance is meeting expectations and if not, to correct course."
- Gaps in investment-relevant data are particularly acute for environmental assets and associated flows of goods, services and risks. These gaps not only arise from the absence of relevant data, but from its fragmentation, accessibility and quality. The Ocean Finance Handbook further notes, "building a system to collect data, and to interpret data in order to provide the information investors need, is therefore a key pre-requisite for investment in the sustainable blue economy".
- Ocean Accounts support finance and investment decisions by providing standardised and integrated statistical time-series that cover connections between a wide range of social, economic and environmental circumstances, and provide the basis for generating relevant indicators and analyses. More specifically, they provide a reporting system that is thematically aligned with the growing range of criteria frameworks for public and private sector investment, including:
    - *Finance ministry appraisal and evaluation criteria:* for example those documented in the UK Government HM Treasury Green Book concerning natural capital and accounting for environmental impacts in policy appraisal,[1] and the New Zealand Living Standards Framework which benchmarks policy impacts against 12 domains of well-being, four capital stocks, and risk and resilience.
    - *Sustainable finance principles:* for example, the Sustainable Blue Economy Finance Principles, and Global Reporting Initiative suite of Standards.
    - *Sustainability certifications:* for example those maintained by the Marine Stewardship Council[5] which require detailed information concerning the status of fisheries resources and associated management measures.

4.3.5 Technical advice and reporting

- *Technical advice:* All of the use cases summarised above depend on technical advice informed by analyses such as cost-benefit assessment, environmental and social impact assessments, and a wide variety of forecasting and modelling techniques. Ocean Accounts provide a broad-scope and standardised data input into the analytical processes, reinforcing the quality of analytical outputs. A range of technical advice use cases for SEEA Accounts are discussed in detail in SEEA 2012: Applications and Extensions —these apply equally to the Ocean Accounts Framework given the general compatibility of the latter with the former. The experimental components of the OAF concerning governance accounting are intended to support a wider range of technical analysis methods that rely on integrated use of qualitative and quantitative information, including but not limited to political economy analysis,[2] system dynamics modelling,[3] agent-based modelling,[4] and governance mapping.

- *Integrated reporting:* The Ocean Accounts Framework provides a holistic structure, that can be used organise the information required for integrated reporting of social, economic and environmental conditions related to oceans. This includes reporting of progress towards national ocean-based and general development objectives, and international commitments including the Paris Agreement on Climate Change, Sendai Framework for Disaster Risk Reduction, Convention on Biological Diversity, and the Sustainable Development Goals (**SDGs**). In particular, Ocean Accounts facilitate the structuring of information relevant to SDG 14 and its ten associated Targets, which call on all countries and stakeholders to conserve and sustainably use the oceans, seas and marine resources for sustainable development.
- *Meeting international commitments:* The compilation of Ocean Accounts directly implements a range of international commitments, including but not limited to: SDG Target 15.9 calling on all countries and stakeholders, by 2020, to integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts; and SDG Target 17.19 calling on all countries and stakeholders, by 2030, to build on existing initiatives to develop measurements of progress on sustainable development that complement Gross Domestic Product, and support statistical capacity-building in developing countries. In addition to these commitments countries have agreed to comprehensive indicator frameworks for the major post-2015 commitments concerning sustainable development, namely the Paris Agreement on Climate Change, Sendai Framework for Disaster Risk Reduction, Addis Ababa Action Agenda on Finance for Sustainable Development, and the 2030 Agenda for Sustainable Development including the SDGs. A selection of specific links between Ocean Accounts and reporting against these commitments are discussed below.

4.3.6 Progress reporting for the post-2015 agreements

- Data availability and supporting methodologies are critical to the assessment, monitoring and reporting of the SDGs. This is particularly relevant to SDG14 where most of the ten proposed indicators were initially classified as tier III. In 2019, the UN Environment's "Measuring Progress Towards Achieving the Environmental Dimension of the SDGs" reported that only three SDG14 indicators had some data, of which two had adequate data for trend analysis (i.e., SDG14.5.1 on MPAs and SDG14.4.1 on sustainable fish stocks). This was echoed in the 2020 Asia and the Pacific SDG Progress Report that progress towards 2030 of eight SDG14 indicators could not be measured. For the two indicators that had sufficient data for statistical reporting (SDG14.5.1 on MPAs and SDG14.1.1 on marine pollution – the latter using OHI as a proxy indicator), amplified efforts are needed if they are to achieve the targets.
- Although five SDG14 indicators are classified as tier I as of 17 April 2020 [11] (i.e., indicator is conceptually clear, has an internationally established methodology and standards are available, and data are regularly produced by at least 50 per cent of the countries and of the population in every region where the indicator is relevant), existence of data are uneven – even in Asia and the Pacific where the Indian and Pacific oceans are housed. The ESCAP's 2020 theme study "Changing Sails: Accelerating Regional Actions for Sustainable Oceans in Asia and the Pacific" highlighted significant knowledge gaps in ocean acidification, fisheries and fishing-related activities, and economic benefits as sufficient data are only available for SDG14.5.1 and a proxy indicator for SDG14.1.1. It concluded that if the paucity of data persists, the Asia-Pacific region is not on track to achieve SDG14 by 2030.
- SDG 14 (to conserve and use the oceans, seas and marine resources for sustainable development) is linked to a multitude of other SDG targets. **Figure 20** below uses a systems analysis approach to uncover links between resilience of oceans, seas, and marine resources (SDG 14) with the other SDGs and their corresponding targets. The left-hand side demonstrates how SDGs and targets can contribute to strengthening resilience, and the right-hand outlines how the SDGs and corresponding targets can in turn be achieved by strengthening resilience. Arrows between the central circle and goals symbolize the direction and depth of each relationship, with a thicker arrow indicating a higher level of impact.

Figure 20 System analysis for SDG14

Source: ESCAP, 2018.

Figure 20. System analysis for SDG14. Source: ESCAP, 2018.

- These arrows reveal the importance of SDG 6 which is related to water pollution, SDG 15 which protects ecosystems and biodiversity, and the Regional Road Map which focuses on transboundary cooperation in the management of climate change and natural resources, for developing resilient oceans, seas and marine resources. Resilience will also be strengthened through efforts to reduce illness caused by pollution (SDG 3), make city infrastructure more sustainable to diminish CO_2 emission (SDG 9), develop clean energy technology through international cooperation (SDG 7), decrease hazardous waste that would otherwise pollute coastal areas (SDG 12) and to intensify climate action through education and adaption plans (SDG 13). The SDGs that will most benefit from strengthened resilience in the oceans, seas and marine resources are SDG 1 which aims to reduce poverty and vulnerability and thus depends on marine livelihoods, and SDG 11 which aims to enhance the safety and resilience of cities and human settlements safer and thus depends on the reduction of ocean acidification. Resilience of oceans, seas and marine resources will also contribute towards ending malnutrition (SDG 2), promoting sustainable economic growth (SDG 8), reducing income inequality (SDG 10), and decreasing violence (SDG 16).

ⓘ [11] As of 17 April 2020, SDG14 included five tier II indicators and five tier I indicators. See UNSD tier classification.

- **Appendix 6.5** provides an initial link between SDG14 and components of the Ocean Accounts Framework.
- The SDGs and the Sendai Framework also have several linkages (**Figure 21**, below). Whilst SDG 14 is not directly linked to the Sendai Framework, a focus on SDG 14 can impact Sendai targets A, B, C and D from an economic standpoint. This demonstrates that the Sendai Framework indicators are related to four of the SDG targets. Compiling data for these indicators will therefore support ESCAP in its aim to synchronize the Sendai Framework with related SDGs, in order to meet resolution 73/7 on "enhancing regional cooperation for the implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030 in Asia and the Pacific".

Figure 21 Links between targets of the Sendai Framework and the SDGs

Figure 21. Links between targets of the Sendai Framework and the SDGs.

- Data concerning coastal communities, infrastructure, ecosystems, and ocean conditions such as SST variability, weather patterns and, phytoplankton levels etc. are required to build understanding of oceans, disaster risk and climate change. However, there are many data gaps that need to be filled to monitor indicators such as those related to coastal infrastructure, disruptions of ocean related services, early warning and risk information services, and that are required for measuring the global targets of the Sendai Framework (and disaster-related targets of the SDGs). This can be generated through linking SDG 14 and the Sendai Framework, through a core set of common statistics (**Figure 22**).

Figure 22 The availability of data to monitor and report on the indicators measuring the global targets of the Sendai Framework and disaster-related targets of the SDGs

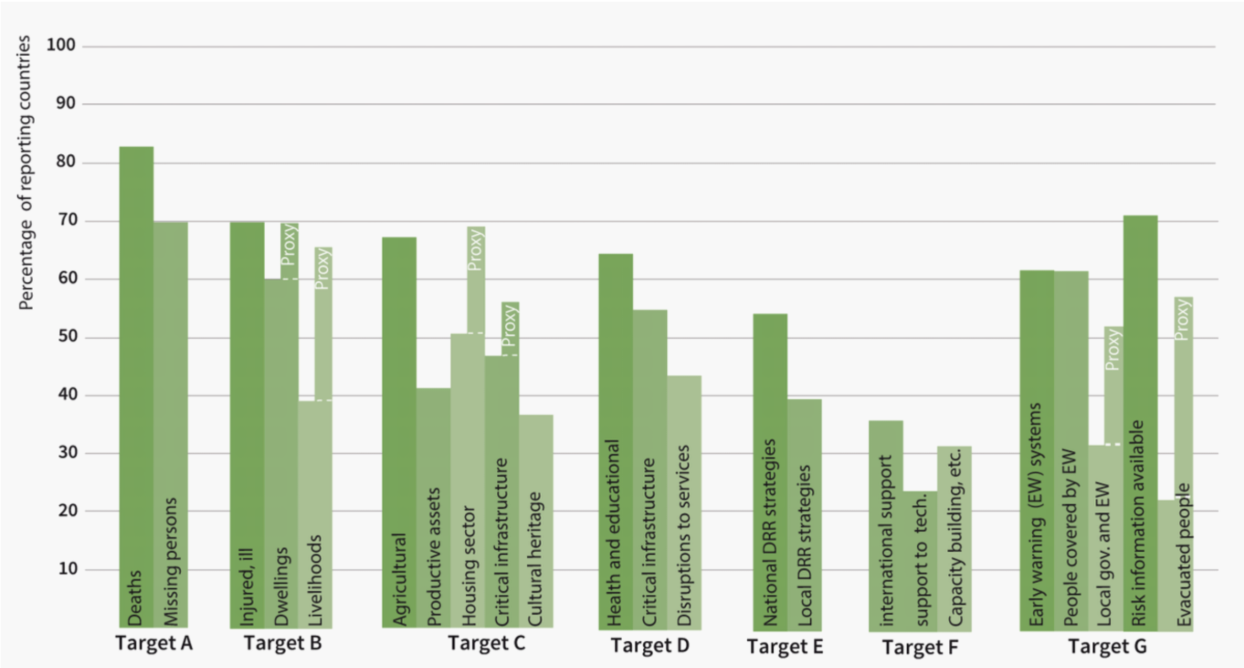


Figure 22 The availability of data to monitor and report on the indicators measuring the global targets of the Sendai Framework and disaster-related targets of the SDGs. Source: Sendai Framework data readiness review 2017 – Global summary report, UNISDR.

4.4 Research use cases for Ocean Accounts

- The structure and data provided by Ocean Accounts provides many opportunities for subsequent research by an interdisciplinary set of physical, biological, ecological, and social scientists. It is important that ocean accounting systems are proactively designed to be able to support a range of research inquiries, and that it be adaptive to results obtained from ongoing research (e.g., new metrics or indicators that should be included).
- Trend analysis is a key potential use for the Ocean Accounts by researchers. With a reliable data sets at multiple scales that are collected at reliable time steps, researchers will be able to use accounts to evaluate how key metrics are evolving over time globally and within specified sub-global regions. For example, a researcher could investigate average global sea surface temperature trends and then evaluate how those trends are different or similar across ocean regions. Drivers for identified trends could then be hypothesized and identified.
- Evaluation of interactions across metrics or indicators included in the ocean accounting system is another likely research use. By compiling consistent data across time and space on physical, ecological, and socioeconomic metrics, the accounting system provides a mechanism for understanding covarying indicators and the nature of their relationship (e.g., proportional or inversely proportional). For example, changes in sea surface temperatures can be correlated with observed changes in fish species distributions to determine if there is a positive correlation between the movement of species and temperature trends; this can also be combined with evaluation of global and national economic indicators for the fishing sector (e.g., its profitability) to evaluate the distribution of impacts from the temperature change. Appropriate controls for other potential drivers of change would need to be included.

- Researchers may also make use of accounting systems to evaluate how political and policy structures influence trends in metrics included in the accounts. Controlling for other variables, this kind of a global data set may allow for improved evaluation of policies that are successful (or at least correlated with) moving an indicator from one level to another. For example, different fishery management systems can be compared with the collected data on fish species impacted by the various management systems.
- The spatial nature of the data collected in the Ocean Accounts would allow for research into the varying global distribution of included indicators over time. This will allow researchers to spatially identify global hot spots of change (whether in fish species location, sea surface temperature, energy exploitation, or other topic areas). Such research can help disentangle broad average global changes to identify specific potential regional areas of concern.
- Finally, the accounts and the research analyses described above can provide guidance and a rationale for future lines of research inquiry. For example, identification of a correlation between a fish species and a sea surface temperature change can suggest further research into the causal mechanism for that correlation. A trend analysis showing a decline in the extent of an upwelling area may likewise prompt research into the drivers that may be causing that change. The advantage of a consistent, publicly available global data set is that it can provide this type of intellectual stimulation for a global network of researchers.

4.5 Enabling factors for ocean accounting

- The UN Decade of Ocean Science for Sustainable Development provides an important opportunity to build on the current interest, need for and momentum for Ocean Accounting. Including Ocean Accounting within the priorities of the UN Decade, would support the integration of knowledge from across scientific domains to ensure coherence for the monitoring and reporting of SDG-14 indicators.
- One of the most critical enabling factors for the implementation of the Ocean Accounting framework is Capacity Building. Access to geo-spatial platforms, large volumes of Earth observation, economic and social science data, innovative use of Artificial Intelligence and Machine Learning algorithms and techniques will be ineffective should these stakeholders not be proficient with the basic tools.
- This Technical Guidance document should therefore also serve as platform to understand the capacity building needs of Member States and their National Statistic Systems. From science, to data access management, to technological tools and methods, the process initiated by this document should be seen as a vehicle for the definition of a capacity building plan for Ocean Accounting needs within Member States.

5. Research agenda for ocean accounting

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- This Guidance is a work in progress and future revisions will benefit from additional research, testing and deliberation among experts and users. **Appendix 6.8** presents a more extensive list of research questions compiled from contributors to this Guidance.
- Some of these questions will benefit from progress in the SEEA Ecosystems revision process. Others will feed into that process.

5.1 Ocean assets

- Including produced capital, such as ports and harbours, and other coastal and marine infrastructure in the asset accounts. This would require developing lists of what those produced assets are and developing methods for representing them in the accounting tables, including assets not covered by the SNA 2008 (see **Defining environmental assets**).
- Including human capital, such as knowledge about the ocean and experience with the ocean. Although these are considered cultural ecosystem services, research would be required to develop appropriate measures and accounting treatments of their contributions to human capital (see **Defining environmental assets**).
- Testing the IUCN Global Ecosystem Typology against national and international (CMECS, CBiCS) classifications (see **Classification of ocean ecosystems**).
- Developing a comprehensive view of monetary asset accounts, one that includes the future flows of SNA and non-SNA benefits (see **Monetary asset accounts** and **Spatial data infrastructure for Ocean Accounts**).

5.2 Flows to the economy (ocean services)

- Linking ecosystem processes with the ecosystem services classification (this is a challenge for ecosystem accounting in general and would benefit from compilation of the many thousands of research studies on individual ecosystems and services) (see **Classification of ocean ecosystem services**).
- Reconciling the “commodity” approach of the SEEA with the “activity” approach of the Ocean Economy Satellite Accounts in establishing physical and monetary flows to the economy (see **Physical flow (supply and use) accounts** and **Ocean economy satellite accounts**).

5.3 Ocean economy

- Putting the ocean economy into context of the whole economy: Developing accounting approaches to establish not only ocean economy satellite accounts, but also to derive equivalents of national balance sheet, balance of trade (imports/exports), fixed capital formation, depreciation/depletion, and non-market goods and services (see **Scope boundaries of Ocean Accounts**).
- Establishing an agreed conceptual framework and classification of characteristic economic activities to support a more standardized approach to Ocean Economy Satellite Accounting (see **Ocean economy satellite accounts**).

- Linking ocean economy satellite accounts to changes in physical and related financial capital (see **Assessing the ocean economy**).

5.4 Combined presentation

- Developing appropriate economic, environmental and social indicators for combined presentations that encapsulate information on assets, conditions, flows at spatial and sectoral disaggregation (see **Combined presentation**).

5.5 Ocean wealth

- Allocating the wealth of corporations, households and governments to the ocean (see **Ocean wealth accounts**).

5.6 Spatial database

- Testing global data, such as the USGS/ESRI Global Shoreline Vector and the General Bathymetric Chart of the Oceans (GEBCO) in national applications (see **Developing a spatial database**).
- Testing various sizes and shapes of Basic Spatial Units, for near-shore and offshore areas (see **Developing a spatial database**).
- Testing 3-dimensional (volume) spatial frameworks and developing approaches that are consistent with area-based (2-dimensional) accounting (see **The spatial data infrastructure for Ocean Accounts**).

6. Appendices

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Appendix 6.1 Global data sources

Table 33. Partial list of ocean data portals.

Name	Source	Ocean specific
Alaska Ocean Observing System	https://portal.aoos.org/	
Copernicus Marine Environment Monitoring Service	http://marine.copernicus.eu/	x
Australian Ocean Data Network	https://portal.aodn.org.au/	x
CCHDO	https://cchdo.ucsd.edu/	x
Coral Reef Science and Cyberinfrastructure Network	https://www.earthcube.org/group/crescynt-coral-reef-science-cyberinfrastructure-network	x
Data Oceanplus	https://data.oceanplus.org/	x
Data4science	https://services.d4science.org/explore	
DataCite	https://search.datacite.org/	

Datadryad	http://datadryad.org/	
DataOne	https://search.dataone.org/data	
Dataverse	https://dataverse.harvard.edu/	
DESEASION	http://recherche.imt-atlantique.fr/deseasion/#features	x
Earth Cube	https://www.earthcube.org/tools-inventory	
EU Open data portal	https://www.opendatasoft.com/a-comprehensive-list-of-all-open-data-portals-around-the-world/	
Global Ocean Data Analysis Project	https://www.glodap.info/index.php/data-access/	x
Global Reef Record	http://www.globalreefrecord.org/	x
Google dataset search	https://toolbox.google.com/datasetsearch	
Google Earth Engine	https://earthengine.google.com/	
Knowledge Network for Biocomplexity	https://knb.ecoinformatics.org/	
Koordinates	https://koordinates.com/about/	
Long Term Ecological Research Network Data Portal	https://portal.lternet.edu/nis/home.jsp	
Marine Regions	http://marineregions.org/downloads.php	x
Mendeley Data	https://data.mendeley.com/	
Mistrals	http://mistrals.sedoo.fr/	
Movebank	https://www.movebank.org/panel_embedded_movebank_webapp	
NASA Ocean Color	https://oceancolor.gsfc.nasa.gov/	x

National Ecological Observatory Network	http://data.neonscience.org/home	
NOAA centers for Environmental Information	https://www.nodc.noaa.gov/access/index.html	
OBIS	http://iobis.org/	x
Ocean Data Platform	https://revocean.org/platform/project	x
Ocean Data Viewer	http://data.unep-wcmc.org/	x
Octopus	https://octopus.zoo.ox.ac.uk/beta	x
OECD	https://data.oecd.org/searchresults/?r=+f/type/datasets	
Pacific Ocean Portal	http://oceanportal.spc.int/portal/ocean.html	x
Pangaea	https://www.pangaea.de/about/	
Re3Data	https://www.re3data.org/	
SeaDataNet	http://seadatanet.maris2.nl/v_cdi_v3/search.asp	x
SeaView	http://www.seaviewdata.org/	x
Sextant (Ifremer)	https://sextant.ifremer.fr/en/geoportail/sextant#/search?from=1&to=20	x
Sextant (Ifremer)	https://sextant.ifremer.fr/en/web/geosciences_marines/geoportail/sextant#/search?from=1&to=20	x
Stats et pêche	http://www.stats-et-peche.fr/	x
TARA Oceans Data Portal	http://www.taraoceans-dataportal.org/top/welcome.html	x
The Coastal EBA Decision Support Tool	http://web.unep.org/coastal-eba/coastal-EBA-DST/	
The European Atlas of the Seas	https://ec.europa.eu/maritimeaffairs/atlas/about_en	x

UK Cetacean Strandings Investigation Programme	http://ukstrandings.org/links/	x
Zendo	https://zenodo.org/	
ReefBase	http://www.reefbase.org/main.aspx	X
World Reef Map	https://maps.lof.org/lof	X
Protected Planet	https://www.protectedplanet.net/	
EMODnet Physics	http://www.emodnet-physics.eu/Portal	X
EMODnet Seabed Habitats	https://www.emodnet-seabedhabitats.eu/	X
EMODnet Chemistry	http://www.emodnet-chemistry.eu/data	X
EMODnet Biology	http://www.emodnet-biology.eu/	X
EMODnet Geology	http://www.emodnet-geology.eu/	X
EMODnet Human Activities	http://www.emodnet-humanactivities.eu/	X

Table 34. Summary of ESCAP Global Ocean Data Inventory

ⓘ Accessible via: https://www.unescap.org/sites/default/files/3.2.A.2_Ocean_Accounts_Global_Ocean_Data_Inventory_GOAP_12-15Nov2019.pdf

Name	**Source**	**Ocean specific**
A Global Self-consistent, Hierarchical, High-resolution Geography Database (GSHHG)	https://www.soest.hawaii.edu/pwessel/gshhg/	X
AlgaeBase	http://www.algaebase.org/	X
AquaMaps	https://www.aquamaps.org/search.php	X

Argo	http://www.argo.net/ http://www.argo.ucsd.edu/ https://www.nodc.noaa.gov/argo/	X
Asia-Pacific Data-Research Centre (APDRT)	http://apdrc.soest.hawaii.edu/index.php	
Atlas of Ocean Wealth	http://oceanwealth.org/resources/atlas-of-ocean-wealth/	X
Biological and Chemical Oceanography Data Management Office (BCO-DMO)	https://www.bco-dmo.org/data	X
Blue Habitats	http://www.bluehabitats.org/?page_id=9	X
British Oceanographic Data Centre (BODC)	https://www.bodc.ac.uk/about/#	X
CNES AVISO+ Satellite Altimetry Data	https://www.aviso.altimetry.fr/en/data.html	X
Coastal & Oceanic Plankton Ecology, Production, & Observation Database (COPEPOD)	https://www.st.nmfs.noaa.gov/plankton/about/databases.html	X
Coastal and Marine Ecological Classification Standard (CMECS)	https://iocm.noaa.gov/cmecs/	X
Combined Biotope Classification Scheme (SBiCS)	http://dev-coastkit.cbics.org/	X
Copernicus Marine Environment Monitoring Service	http://marine.copernicus.eu/	X
Coriolis Argo New Displacements Rannou and Ollitrault (ANDRO) An Argo-based deep displacement atlas	https://www.seanoe.org/data/00360/47077/	X
Coriolis Ocean Dataset for Reanalysis (CORA)	http://www.coriolis.eu.org/Data-Products/Products/CORA	X
Coriolis Operational Oceanography	http://www.coriolis.eu.org/Data-Products/Data-Delivery/Data-selection	X

DATO.GOV Ocean Data Catalog	https://www.data.gov/ocean/	X
dbSEABED	https://instaar.colorado.edu/~jenkinsc/dbseabed/	X
ESRI Ecological Marine Units	https://esri.maps.arcSHP.com/home/group.html?id=6c78a5125d3244f38d1bc732ef0ee743#overview	X
ESRI Living Atlas	https://livingatlas.arcSHP.com/en/	
ESSO Indian National Centre for Ocean Information Services	https://www.incois.gov.in/portal/osf/osf.jsp	X
Everyone's Gliding Observatories (EGO)	https://www.ego-network.org/dokuwiki/doku.php	X
FAO Global fishery databases	http://www.fao.org/fishery/topic/16054/en	X
FishBase	https://www.fishbase.se/home.htm	X
FleetMon	https://www.fleetmon.com/	X
General Bathymetric Chart of the Oceans (GEBCO)	https://www.gebco.net/	X
Global Earth Observation System of Systems' Platform (GEOSS Platform)	http://www.earthobservations.org/gci.php http://www.geoportal.org/	
Global Fishing Watch	http://globalfishingwatch.org/research/research-accelerator-program/	X
Global Integrated Shipping Information System	https://gisis.imo.org/Public/Default.aspx	X
Global Island Database (GID)	http://www.globalislands.net/about/gid_functions.php	X
Global Islands Explorer (GIE) Data: Global Shoreline Vector (GSV) and Global Ecological Coastal Units (ECUs)	Introductio: https://rmgsc.cr.usgs.gov/gie/ Online Viewer: https://rmgsc.cr.usgs.gov/gie/gie.shtml Data download: https://rmgsc.cr.usgs.gov/outgoing/ecosystems/Global/	X

Global Ocean acidification observing network (GOA - ON) data portal	http://portal.goa-on.org/Home	X
Global Ocean Data Assimilation Experiment (GODAE)	https://www.usgodae.org/index.html	X
Global Ocean Ship-based Hydrographic Investigations Program (GO-SHIP)	http://www.go-ship.org/DataDirect.html	X
Global Species Databases (GSD)	http://marinespecies.org/subregisters.php#species_dbs_GSD	X
Global Temperature and Salinity Profile Programme (GTSPP)	https://www.nodc.noaa.gov/GTSPP/	X
GOOS Surface Ocean CO2 Atlas (SOCAT)	https://www.socat.info/index.php/data-access/	X
Group For High Resolution Sea Surface Temperature (GHRSST)	https://www.ghrsst.org/	X
Hadley Centre Observation Datasets	https://www.metoffice.gov.uk/hadobs/	X
Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite Data (HOAPS)	https://climatedataguide.ucar.edu/climate-data/hoaps-hamburg-ocean-atmosphere-parameters-and-fluxes-satellite-data	X
International Chamber of Shipping (ICS)	http://www.ics-shipping.org	X
International Ocean Discovery Program (IODP)	http://www.iodp.org/resources/access-data-and-samples	X
International Seabed Authority Maps	https://www.isa.org.jm/maps	X
Island Directory	http://islands.unep.ch/isldir.htm	X
IUCN & WCMC Protect Planet Ocean	http://www.protectplanetocean.org/	X

JCOMM in situ Observations Programme Support Centre (JCOMMOPS)	https://www.jcomm.info/index.php?option=com_oe&task=viewGroupRecord&groupID=126	X
Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS)	http://www.legos.obs-mip.fr/legos/Presentation	X
Large Marine Ecosystems (LMEs)	http://lme.edc.uri.edu/	X
LEGOS Center for Topogaphic studies of the Ocean and Hydrosphere (CTOH)	http://ctoh.legos.obs-mip.fr/	X
LEGOS Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS)	http://www.legos.obs-mip.fr/observations/doris	X
LEGOS Prediction and Research Moored Array in the Tropical Atlantic (PIRATA)	http://www.brest.ird.fr/pirata/index.php	X
LEGOS ROSAME Tide Gauges Network	http://www.brest.ird.fr/pirata/index.php	X
LEGOS Sea Surface Salinity Observation Service	http://www.legos.obs-mip.fr/observations/sss	X
LITTERBASE	https://litterbase.awi.de/	X
Long Term Ecological Research (LTER) Network Data Portal	https://www.iode.org/index.php?option=com_content&view=article&id=178:data-access&catid=33&Itemid=141#global	X
Marine Network for Integrated Data Access (MANIDA)	https://www.manida.org/	X
Marine traffic	https://www.marinetraffic.com/	X
NASA bio-Optical Marine Algorithm Dataset (NOMAD)	https://seabass.gsfc.nasa.gov/wiki/NOMAD	X
NASA Earth Observations	https://neo.sci.gsfc.nasa.gov/	

NASA National Snow & Ice Data Center	http://nsidc.org/data/modis/data_summaries#sea-ice	
NASA Physical Oceanography Distributed Active Archive Center (PODAAC)	https://podaac.jpl.nasa.gov/datasetlist	X
NASA SeaWiFS Bio-optical Archive and Storage System (SeaBASS)	https://seabass.gsfc.nasa.gov/wiki/System_Description	X
NASA State of the Ocean (SOTO) Version 4.2.1	https://podaac-tools.jpl.nasa.gov/soto/	X
NASS Moderate Resolution Imaging Spectroradiometer (MODIS)	https://modis.gsfc.nasa.gov/data/	X
NOAA - Coral Reef Temperature Anomaly Database (CoRTAD)	https://www.nodc.noaa.gov/SatelliteData/Cortad/	X
NOAA One Stop	https://data.noaa.gov/onestop/#/	X
NOAA Advanced Very High Resolution Radiometer (AVHRR)	https://earth.esa.int/web/guest/missions/3rd-party-missions/current-missions/noaa-avhrr	
NOAA Blended In Situ-CZCS Chlorophyll Data Set	https://www.nodc.noaa.gov/OC5/WOA98/pr_chlr.html	X
NOAA Coral Reef Information System (CoRIS)	https://www.coris.noaa.gov/ https://www.coris.noaa.gov/search/catalog/main/home.page	X
NOAA Deep Sea Coral Data Portal (DSCRTP)	https://deepseacoraldata.noaa.gov/ https://www.ncei.noaa.gov/maps/deep-sea-corals/mapSites.htm	X
NOAA ETOPO1 Global Relief Model	https://www.ngdc.noaa.gov/mgg/global/global.html	X
NOAA Global Data Explorer	https://www.nnvl.noaa.gov/view/globaldata.html	X
NOAA Global Ocean Heat and Salt Content	https://www.nodc.noaa.gov/OC5/3M_HEAT_CONTENT/	X
NOAA Gridded Climate Datasets	https://www.esrl.noaa.gov/psd/data/gridded/	X

NOAA Marine Geology and Geophysics	https://www.ngdc.noaa.gov/mgg/mggd.html	X
NOAA National Data Buoy Center (NDBC)	https://www.ndbc.noaa.gov/	X
NOAA Naval Oceanographic Office Global Hybrid Coordinate Ocean Model (HYCOM)	https://hycom.org/dataserver	X
NOAA NCEI Ocean Color Archive	https://www.nodc.noaa.gov/SatelliteData/OceanColor/	X
NOAA NCEI Ocean Surface Topography Mission (OSTM) / Jason-2 and Jason-3 Satellite Products Archive	https://www.nodc.noaa.gov/SatelliteData/jason/	X
NOAA NCEP Global Ocean Data Assimilation System (GODAS)	http://www.cpc.ncep.noaa.gov/products/GODAS/	X
NOAA Ocean Carbon Data System (OCADS) (formerly CDIAC-Oceans)	https://www.nodc.noaa.gov/ocads/	X
NOAA Oxygen / Apparent Oxygen Utilization (AOU) Content	https://www.nodc.noaa.gov/cgi-bin/OC5/PENTAS/ anomalydata.pl?parameter=oxy	X
NOAA Pacific Marine Environmental Laboratory (PMEL)	https://www.pmel.noaa.gov/about-pmel	X
NOAA Quality Monitoring on Level-2 Sea Surface Salinity (SSS) Products from SMAP, SMOS and Aquarius Missions	https://www.nodc.noaa.gov/SatelliteData/sss/	X
NOAA Satellite Ocean Heat Content Suite (SOHCS)	https://data.nodc.noaa.gov/cgi-bin/iso? id=gov.noaa.nodc:NESDIS-OHC	X
NOAA World Ocean Atlas 2013 Version 2	https://www.nodc.noaa.gov/OC5/woa13/	X
NOAA World Ocean Database (WOD)	https://www.nodc.noaa.gov/OC5/WOD/pr_wod.html	X

Objective Analyzed air-sea Fluxes (OAFlux) for the Global Oceans	http://oaflux.whoi.edu/dataproducts.html	X
Ocean Health Index (OHI)	http://www.oceanhealthindex.org/	X
Ocean Observatories Initiative (OOI)	http://oceanobservatories.org/data/	X
OceanSITES	http://www.oceansites.org/index.html	X
Partnership for Observation of the Global Oceans (POGO) - ocean-going Research Vessels	http://www.pogo-oceancruises.org/v_pogo_v1/browse_step.asp	X
Peace Research Institute Oslo (PRIO) - Petroleum Dataset	https://www.prio.org/Data/Geographical-and-Resource-Datasets/Petroleum-Dataset/Petroleum-Dataset-v-12/	X
Permanent Service for Mean Sea Level (PSMSL)	http://www.psmsl.org/data/	X
Reefs at Risk Revisited	http://www.wri.org/publication/reefs-risk-revisited	X
Rolling Deck to Repository (R2R) Data Repository	https://www.rvdata.us/data	X
Sea Around Us	http://www.seaaroundus.org/	X
Sea Level Station Monitoring Facility	https://uhslc.soest.hawaii.edu/datainfo/	X
SEA scieNtific Open data Edition (Seanoe)	http://www.seanoe.org/	X
SeaLifeBase	https://www.sealifebase.ca/	X
Sentinel Online	https://sentinels.copernicus.eu/web/sentinel/thematic-areas/marine-monitoring http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Marine_services	X
Shipmap	https://www.shipmap.org/	X

The International Comprehensive Ocean-Atmosphere Data Set (ICOADS)	https://icoads.noaa.gov/	X
The International Council for the Exploration of the Sea (ICES)	https://www.ices.dk/Pages/default.aspx	X
The Shipboard Automated Meteorological and Oceanographic System (SAMOS)	https://samos.coaps.fsu.edu/html/docs/NOAA-TM_OAR_PSD-311.pdf	X
The United States Geological Survey (USGS)	https://www.usgs.gov/science/science-explorer/Oceans	X
Tropical Ocean Global Atmosphere (TOGA) Coupled Ocean Atmosphere Response Experiment (COARE) TOGA/COARE	https://www.coaps.fsu.edu/COARE/coaremet.html	X
UNCTADstat	http://www.unece.org/cefact/locode/welcome.html	
UNESCO/IOC - Ocean Data Portal	http://www.oceandataportal.org/	X
UNESCO/IOC Global Ocean Surface Underway Data (GOSUD)	http://www.gosud.org/	X
UNESCO/IOC Harmful Algal Bloom Program (HAIS)	http://hab.ioc-unesco.org/ Online Map: http://envlit.ifremer.fr/var/envlit/storage/documents/parammaps/haedat/ CSV Data: http://haedat.iode.org/browseEvents.php	X
UNESCO/IOC Sea Level Facility	http://www.ioc-sealevelmonitoring.org/	X
UNESCO/IOC The Global Ocean Observation System	http://www.goosocean.org/	X
Unidata	https://www.unidata.ucar.edu/data/	
University of Hawaii Sea Level Center	http://uhslc.soest.hawaii.edu/datainfo/	X
US National Center for Atmospheric Research/research data archive (NCAR/RDA)	https://rda.ucar.edu/	X

WCMC Ocean Data Viewer	http://data.unep-wcmc.org/	X
WMO&IOC Data Buoy Cooperation Panel (DBCP)	http://www.jcommops.org/dbcp/data/access.html	X
World Register of Marine Species (WORMS)	http://marinespecies.org/aphia.php?p=checklist	X
WWF Marine Ecoregions of the World (MEOW)	https://www.worldwildlife.org/publications/marine-ecoregions-of-the-world-a-bioregionalization-of-coastal-and-shelf-areas	X

Appendix 6.2 IUCN global ecosystem typology (selected as relevant to Ocean Accounts)

Table 35. Selected biomes and ecosystem functional groups relevant to ocean accounting. Note: Transitional functional groups, FM1 = Freshwater/Marine; MT1 = Marine/Terrestrial, MFT = Marine/Terrestrial/Freshwater

ⓘ Accessible via: https://iucnrle.org/about-rle/ongoing-initiatives/global-ecosystem-typology/. See also https://global-ecosystems.org/.

Realm	Biome	Ecosystem Functional Group
Subterranean - Marine	SM1 Subterranean tidal biome	SM1.1 Anchialine caves
Freshwater - Marine	FM1 Transitional waters biome (Freshwater Marine)	FM1.1 Deepwater coastal inlets
		FM1.2 Permanently open riverine estuaries and bays
		FM1.3 Intermittently closed and open lakes and lagoons
Marine	M1 Marine shelf biome	M1.1 Seagrass meadows
		M1.2 Kelp forests
		M1.3 Photic coral reefs

		M1.4 Shellfish beds and reefs
		M1.5 Photo-limited marine animal forests
		M1.6 Subtidal rocky reefs
		M1.7 Subtidal sand beds
		M1.8 Subtidal mud plains
		M1.9 Upwelling zones
	M2 Pelagic ocean waters biome	M2.1 Epipelagic ocean waters
		M2.2 Mesopelagic ocean waters
		M2.3 Bathypelagic ocean waters
		M2.4 Abyssopelagic ocean waters
		M2.5 Sea ice
	M3 Deep sea floors biome	M3.1 Continental and island slopes
		M3.2 Submarine canyons
		M3.3 Abyssal plains
		M3.4 Seamounts, ridges and plateaus
		M3.5 Deepwater biogenic beds
		M3.6 Hadal trenches and troughs
		M3.7 Chemosynthetic-based ecosystems (CBE)
	M4 Anthropogenic marine biome	M4.1 Submerged artificial structures
		M4.2 Marine aquafarms

Marine - Terrestrial	MT1 Shorelines biome	MT1.1 Rocky shorelines
		MT1.2 Muddy shorelines
		MT1.3 Sandy Shorelines
		MT1.4 Boulder and cobble shores
	MT2 Supralittoral coastal biome	MT2.1 Coastal shrublands and grasslands
	MT3 Anthropogenic shorelines biome	MT3.1 Artificial shorelines
Marine - Freshwater - Terrestrial	MFT1 Brackish tidal biome	MFT1.1 Coastal river deltas
		MFT1.2 Intertidal forests and shrublands
		MFT1.3 Coastal saltmarshes

Appendix 6.3 List of coastal and marine ecosystem services

- Ocean ecosystem services should be classified so they can be consistently organised within the ocean accounting framework over time. The CICES and FEGS/NESCS approaches (see **Tables 36** and **37** and **Figures 23** below) provide systematic coding structures but imply different scopes. CICES is more of a checklist of often-analysed ecosystem services and, while including many "final" services (i.e., "those directly enjoyed, consumed or used to yield human well-being" (Boyd and Banzhaf, 2007, p619)), it also includes many, such as regulating and maintenance services, that are less-directly used. It also includes services that have less direct link to ecosystem processes, such as cultivated crops. This has the benefit of being broad and therefore able to classify past studies. The newest revision also highlights those services most often associated with marine ecosystems.
- FEGS/NESCS services overlap in scope only for services that are directly used and directly linked to ecosystem processes. As such, it excludes most regulating and maintenance services and cultivated products. However, since it links ecosystem types, with service categories and beneficiaries, it can support a more coherent valuation of a narrower set of services. Ongoing conclusions from the SEEA Revision process concerning ecosystem services classification will be progressively incorporated into this Guidance.
- There is a risk in being over-specific in defining what counts as an ecosystem service. We likely cannot be comprehensive in detailing very specific ecosystem services (partly because we do not know how to mechanistically link ecosystems with human well-being across all possible links). Being too specific can easily reflect the values embedded in the people establishing the categorization. A more flexible classification approach that lacks a coding structure has been developed by IPBES as a conceptual basis for its assessment reports. This broad two-dimensional classification of Nature's Contributions to People is illustrated in **Figure 24** below.

Table 36. Marine-related ecosystem services flagged in the CICES.

Section	Division	Group	Class	Code
Provisioning (Biotic)	Biomass	Cultivated aquatic plants for nutrition, materials or energy	Plants cultivated by in- situ aquaculture grown for nutritional purposes	1.1.2.1
			Fibres and other materials from in-situ aquaculture for direct use or processing (excluding genetic materials)	1.1.2.2
			Plants cultivated by in- situ aquaculture grown as an energy source	1.1.2.3
		Reared aquatic animals for nutrition, materials or energy	Animals reared by in-situ aquaculture for nutritional purposes	1.1.4.1
			Fibres and other materials from animals grown by in-situ aquaculture for direct use or processing (excluding genetic materials)	1.1.4.2
			Animals reared by in-situ aquaculture as an energy source	1.1.4.3
		Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Wild plants (terrestrial and aquatic, including fungi, algae) used for nutrition	1.1.5.1

			Fibres and other materials from wild plants for direct use or processing (excluding genetic materials)	1.1.5.2
			Wild plants (terrestrial and aquatic, including fungi, algae) used as a source of energy	1.1.5.3
			Wild animals (terrestrial and aquatic) used for nutritional purposes	1.1.6.1
			Fibres and other materials from wild animals for direct use or processing (excluding genetic materials)	1.1.6.2
			Wild animals (terrestrial and aquatic) used as a source of energy	1.1.6.3
	Genetic material from all biota (including seed, spore or gamete production)	Genetic material from plants, algae or fungi	Seeds, spores and other plant materials collected for maintaining or establishing a population	1.2.1.1
			Higher and lower plants (whole organisms) used to breed new strains or varieties	1.2.1.2

			Individual genes extracted from higher and lower plants for the design and construction of new biological entities	1.2.1.3
		Genetic material from animals	Animal material collected for the purposes of maintaining or establishing a population	1.2.2.1
			Wild animals (whole organisms) used to breed new strains or varieties	1.2.2.2
			Individual genes extracted from organisms for the design and construction of new biological entities	1.2.2.3
	Other types of provisioning service from biotic sources	Other	Other	1.3.X.X
Regulation & Maintenance (Biotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Bio-remediation by micro-organisms, algae, plants, and animals	2.1.1.1
			Filtration/ sequestration/ storage/ accumulation by micro-organisms, algae, plants, and animals	2.1.1.2
		Mediation of nuisances of anthropogenic origin	Smell reduction	2.1.2.1
			Visual screening	2.1.2.3

	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	Control of erosion rates	2.2.1.1
			Buffering and attenuation of mass movement	2.2.1.2
			Hydrological cycle and water flow regulation (Including flood control, and coastal protection)	2.2.1.3
		Lifecycle maintenance, habitat and gene pool protection	Pollination (or 'gamete' dispersal in a marine context)	2.2.2.1
			Seed dispersal	2.2.2.2
			Maintaining nursery populations and habitats (Including gene pool protection)	2.2.2.3
		Pest and disease control	Pest control (including invasive species)	2.2.3.1
			Disease control	2.2.3.2
		Regulation of soil quality	Decomposition and fixing processes and their effect on soil quality	2.2.4.2
		Water conditions	Regulation of the chemical condition of salt waters by living processes	2.2.5.2

		Atmospheric composition and conditions	Regulation of chemical composition of atmosphere and oceans	2.2.6.1
			Regulation of temperature and humidity, including ventilation and transpiration	2.2.6.2
	Other types of regulation and maintenance service by living processes	Other	Other	2.3.X.X
Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment	Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions	3.1.1.1
			Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions	3.1.1.2
		Intellectual and representative interactions with natural environment	Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge	3.1.2.1

			Characteristics of living systems that enable education and training	3.1.2.2
			Characteristics of living systems that are resonant in terms of culture or heritage	3.1.2.3
			Characteristics of living systems that enable aesthetic experiences	3.1.2.4
	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with natural environment	Elements of living systems that have symbolic meaning	3.2.1.1
			Elements of living systems that have sacred or religious meaning	3.2.1.2
			Elements of living systems used for entertainment or representation	3.2.1.3
		Other biotic characteristics that have a non-use value	Characteristics or features of living systems that have an existence value	3.2.2.1
			Characteristics or features of living systems that have an option or bequest value	3.2.2.2
	Other characteristics of living systems that have cultural significance	Other	Other	3.3.X.X

Table 37. CICES marine-related abiotic services (not flagged by the CICES, but selected by the authors).

Section	Division	Group	Class	Code
Provisioning (Abiotic)	Water	Surface water used for nutrition, materials or energy	Surface water used as a material (non-drinking purposes)	4.2.1.2
			Coastal and marine water used as energy source	4.2.1.4
		Other aqueous ecosystem outputs	Other	4.2.X.X
	Non-aqueous natural abiotic ecosystem outputs	Mineral substances used for nutrition, materials or energy	Mineral substances used for nutritional purposes	4.3.1.1
			Mineral substances used for material purposes	4.3.1.2
			Mineral substances used for as an energy source	4.3.1.3
		Non-mineral substances or ecosystem properties used for nutrition, materials or energy	Non-mineral substances or ecosystem properties used for nutritional purposes	4.3.2.1
			Non-mineral substances used for materials	4.3.2.2
			Wind energy	4.3.2.3
			Solar energy	4.3.2.4
			Geothermal	4.3.2.5

		Other mineral or non-mineral substances or ecosystem properties used for nutrition, materials or energy	Other	4.3.2.6
Regulation & Maintenance (Abiotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of waste, toxics and other nuisances by non-living processes	Dilution by freshwater and marine ecosystems	5.1.1.1
			Dilution by atmosphere	5.1.1.2
			Mediation by other chemical or physical means (e.g. via Filtration, sequestration, storage or accumulation)	5.1.1.3
		Mediation of nuisances of anthropogenic origin	Mediation of nuisances by abiotic structures or processes	5.1.2.1
	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	Mass flows	5.2.1.1
			Liquid flows	5.2.1.2
			Gaseous flows	5.2.1.3
		Maintenance of physical, chemical, abiotic conditions	Maintenance and regulation by inorganic natural chemical and physical processes	5.2.2.1
	Other type of regulation and maintenance service by abiotic processes	Other	Other	5.3.X.X

Cultural (Abiotic)	Direct, in-situ and outdoor interactions with natural physical systems that depend on presence in the environmental setting	Physical and experiential interactions with natural abiotic components of the environment	Natural, abiotic characteristics of nature that enable active or passive physical and experiential interactions	6.1.1.1
		Intellectual and representative interactions with abiotic components of the natural environment	Natural, abiotic characteristics of nature that enable intellectual interactions	6.1.2.1
	Indirect, remote, often indoor interactions with physical systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with the abiotic components of the natural environment	Natural, abiotic characteristics of nature that enable spiritual, symbolic and other interactions	6.2.1.1
		Other abiotic characteristics that have a non-use value	Natural, abiotic characteristics or features of nature that have either an existence, option or bequest value	6.2.2.1
	Other abiotic characteristics of nature that have cultural significance	Other	Other	6.3.X.X

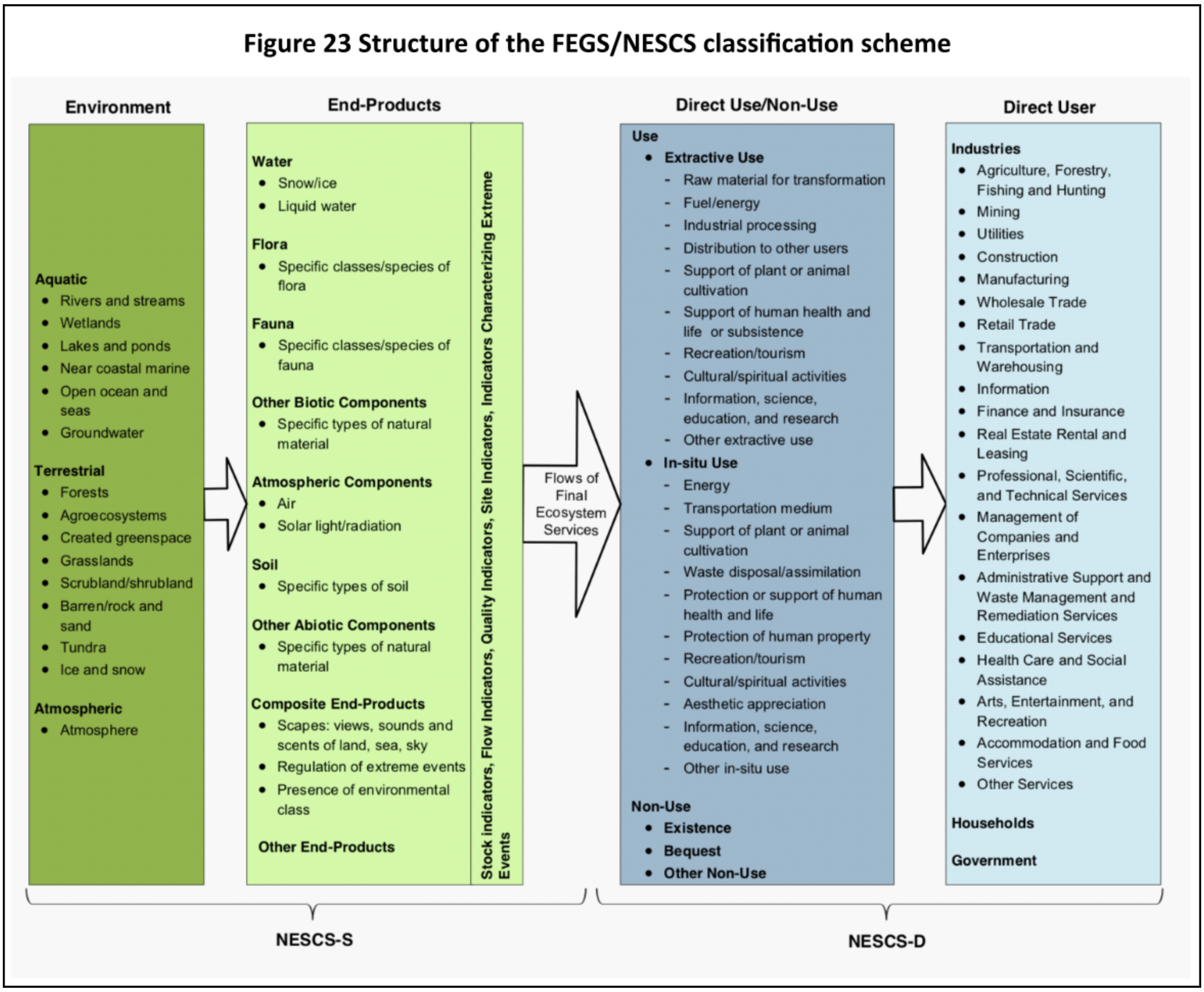

Figure 23. Structure of the FEGS/NESCS classification scheme.

Figure 24 IPBES Classification of Nature's Contributions to People

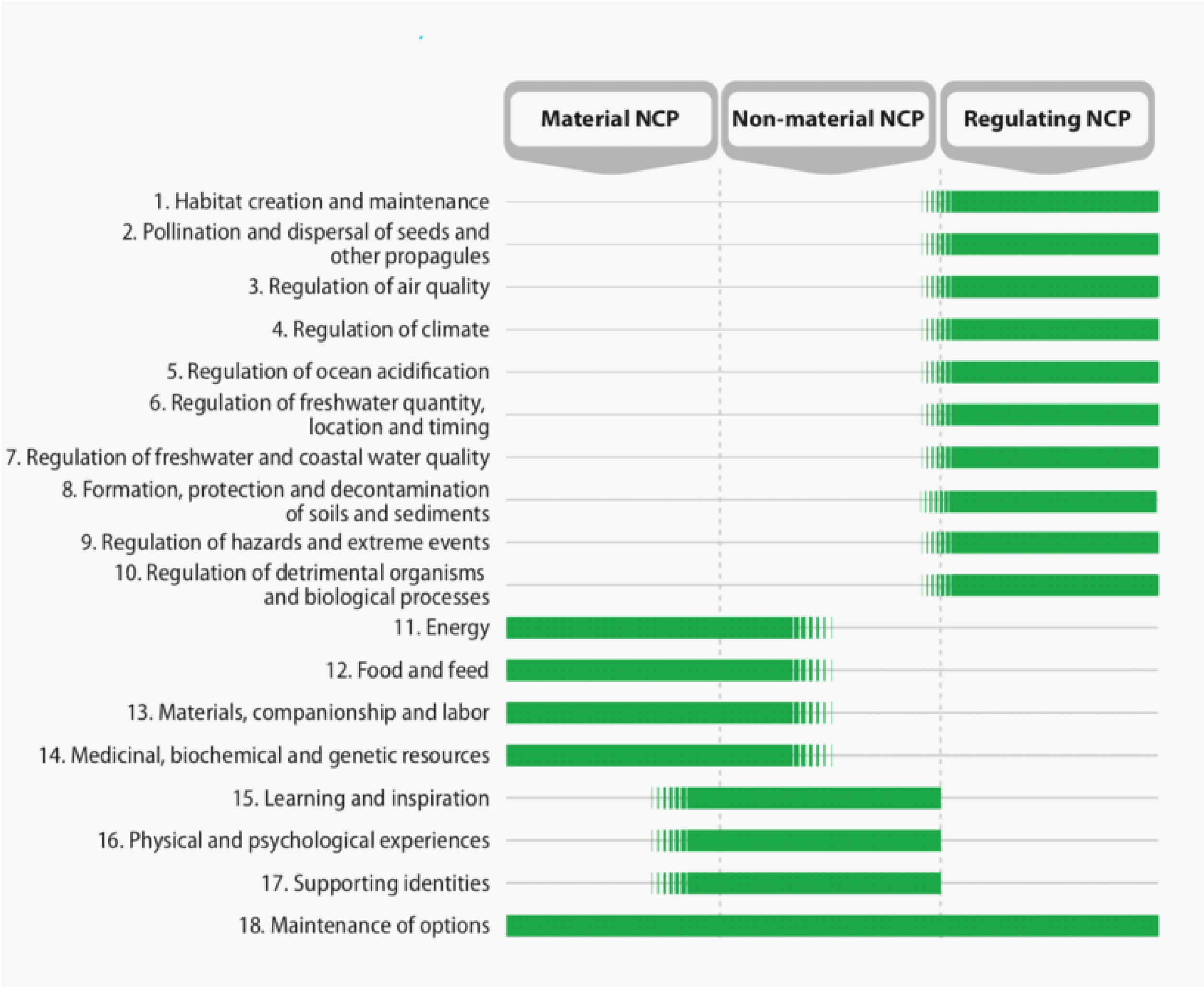

Figure 24. IPBES Classification of Nature's Contributions to People.

Appendix 6.4 Potential FDES (2013) topics and statistics applicable to Ocean Accounts

1. The table provides a basic indication of FDES (2013) topics and statistics which may be relevant to the proposed set of Ocean Accounts. This is a broad indication given that the ocean accounts are in development and is thus subject to further refinement. It draws particularly on the August 2018 workshop concept note. Source: United Nations Statistics Division. Unpublished.

#	Proposed Ocean Accounts	Disaggregation	FDES Component, Sub-component and Topic	FDES Statistic	Notes
	Source: Appendix 1 Concept Note ESCAP Expert Workshop on Ocean Accounts 1-3 August 2018	*National, international waters, sub-national (bay, coastline). In general, FDES would need to be more specific about the spatial areas to cover.*	*Further work is necessary to identify the ocean related spatial areas.*	*Statistics have been proposed where possible, otherwise only the FDES (2013) Topic level is provided and the statistics cell is not yet completed.*	
	Drivers/Pressures				
1	Air emissions (GHGs and others)		Component 3: Residuals, Sub-component 3.1: Emissions to Air, Topic 3.1.1: Emissions of greenhouse gases		
2	Effluents Water flows to the ocean Solid wastes Plastics Hazardous waste		Component 3: Residuals, Sub-component 3.2: Generation and Management of Wastewater, Topic 3.2.3: Discharge of wastewater to the environment	· 3.2.3.a.2: Wastewater discharge: Total volume of wastewater discharged to the environment without treatment	Would need to specify at risk areas.

			Component 3: Residuals, Sub-component 3.3: Generation and Management of Waste: Topic 3.3.1 Generation of Waste and Topic 3.3.2: Management of Waste		
			Component 2: Environmental Resources and their Use, Sub-component 2.2: Energy Resources, Topic 2.2.2: Production, trade and consumption of energy		HS Chapter Code 39 Plastics and articles thereof. Plastics would have to be specified for oceans.
			Component 3: Residuals, Sub-component 3.3: Generation and Management of Waste: Topic 3.3.1 Generation of Waste and Topic 3.3.2: Management of Waste	· 3.3.1.c: Amount of hazardous waste generated · 3.3.2.b: Hazardous Waste	

3	Impact of Agriculture, Forestry, Fisheries		Component 2: Environmental Resources and their Use, Sub-component 2.5: Biological Resources, Topic 2.5.1: Timber resources, Topic 2.5.2: Aquatic resources, Topic 2.5.3: Crops and Topic 2.5.4: Livestock		
			Component 2: Environmental Resources and their Use, Sub-component 3.4: Release of Chemical Substances, Topic 3.4.1: Release of chemical substances		
4	Land use	`	Component 2: Environmental Resources and their Use, Sub-component 2.3: Land, Topic 2.3.1: Land use		
5	Water consumption		Component 2: Environmental Resources and their Use, Sub-component 2.6: Water resources, Topic 2.6.2: Abstraction, use and returns of water		

6	Energy consumption		Component 2: Environmental Resources and their Use, Sub-component 2.2: Energy Resources, Topic 2.2.2: Production, trade and consumption of energy		
	Assets (Extent)				
7	Ocean ecosystem types Benthic (sea bottom) Pelagic (surface) Coastal Open ocean ecosystems	Vertical dimension needed	Component 1: Environmental Conditions and Quality, Sub-component 1.2: Land Cover, Ecosystems and Biodiversity, Topic 1.2.2: Ecosystems and biodiversity	· 1.2.2.a.1: General ecosystem characteristics, extent and pattern: Area of ecosystems	FDES would need to develop guidance on specific ocean ecosystems.
			Component 1: Environmental Conditions and Quality, Sub-component 1.1: Physical Conditions, Topic 1.1.2: Hydrographical characteristics	· 1.1.2.e.1: Coastal waters · 1.1.2.e.2: Territorial sea · 1.1.2.e.3: Exclusive Economic Zone · 1.1.2.e.4: Sea level · 1.1.2.e.5: Area of sea ice	

			Component 1: Environmental Conditions and Quality, Sub-component 1.1: Physical Conditions, Topic 1.1.3: Geological and geographical information		
8	Protected areas		Component 1: Environmental Conditions and Quality, Sub-component 1.2: Land Cover, Ecosystems and Biodiversity, Topic 1.2.2: Ecosystems and biodiversity	· 1.2.2.d.1: Protected areas and species: Protected terrestrial and marine area	
9	Fishing zones		Component 1: Environmental Conditions and Quality, Sub-component 1.1 Physical Conditions, Topic 1.1.2: Hydrographical characteristics		FDES covers physical characteristics but this item is not specified in the statistics. Would be obtained from nautical chart.
10	Ocean mineral assets		Component 2: Environmental Resources and their Use, Sub-component 2.1: Mineral Resources, Topic 2.1.1: Stocks and changes of mineral resources		FDES specifies sub-national breakdown, would need to specify types of minerals from ocean areas.

11	Ocean energy assets		Component 2: Environmental Resources and their Use, Sub-component 2.2: Energy Resources, Topic 2.2.1: Stocks and changes of energy resources		FDES specifies sub-national breakdown, would need to specify types of energy from ocean areas.
12	Ocean communities		Component 5: Human Settlements and Environmental Health, Sub-component 5.1: Human Settlements, Topic 5.1.1: Urban and rural population	· 5.1.1.e: Population living in coastal areas	FDES would need to add spatial area of the village/ community.
13	Coastal and marine infrastructure		Component 1:Environmental Conditions and Quality, Sub-component 1.1: Physical Conditions, Topic 1.1.2: Hydrographical characteristics		FDES covers physical characteristics but this item is not specified in the statistics. Would be obtained from nautical chart.
14	Depths		Component 1: Environmental Conditions and Quality, Sub-component 1.1: Physical Conditions, Topic 1.1.2: Hydrographical characteristics	· 1.1.2.e: Seas	FDES covers physical characteristics but this item is not specified in the statistics. Would be obtained from bathymetric chart.

15	Shipping Lanes		Component 1: Environmental Conditions and Quality, Sub-component 1.1 Physical Conditions, Topic 1.1.2: Hydrographical characteristics	· 1.1.2.e: Seas	FDES covers physical characteristics but this item is not specified in the statistics. Would be obtained from nautical chart.
16	Upwelling Areas		Component 1: Environmental Conditions and Quality, Sub-component 1.1 Physical Conditions, Topic 1.1.2: Hydrographical characteristics	· 1.1.2.e: Seas	FDES covers physical characteristics but this item is not specified in the statistics.
17	Aquatic resources		Component 2: Environmental Resources and their Use, Sub-component 2.5: Biological Resources, Topic 2.5.2: Aquatic resources		
	Condition (Accessibility and Quantity)				
18	Acidification		Component 1: Environmental Conditions and Quality, Sub-component 1.3: Environmental Quality, Topic 1.3.3: Marine Water Quality, Topic 1.3.3: Marine water quality	· *1.3.3.f.1: Physical and chemical characteristics: pH/Acidity/ Alkalinity*	

19	Eutrophication		Component 1: Environmental Conditions and Quality, Sub-component 1.3: Environmental Quality, Topic 1.3.3: Marine Water Quality	· 1.3.3.a: Nutrients and chlorophyll · 1.3.3.a.1: Concentration level of nitrogen · 1.3.3.a.2: Concentration level of phosphorous · 1.3.3.a.3: Concentration level of chlorophyll A	
20	Phytoplankton distribution		Component 1: Environmental Conditions and Quality, Sub-component 1.3: Environmental Quality, Topic 1.3.3: Marine Water Quality, Topic 1.3.3: Marine water quality	· 1.3.3.e.2: Concentration levels of marine organisms	FDES would need to specify phytoplankton.
21	Plastics		Component 1: Environmental Conditions and Quality, Sub-component 1.3: Environmental Quality, Topic 1.3.3: Marine Water Quality, Topic 1.3.3: Marine water quality	· *1.3.3.h.1: Plastic waste and other marine debris: Amount of plastic waste and other debris in marine waters*	

22	Carbon		Component 1: Environmental Conditions and Quality, Sub-component 1.3: Environmental Quality, Topic 1.3.3: Marine Water Quality, Topic 1.3.3: Marine water quality		FDES does not specify oceans dissolved carbon dioxide concentrations.
23	Coral bleaching		Component 1: Environmental Conditions and Quality, Sub-component 1.3: Environmental Quality, Topic 1.3.3: Marine Water Quality, Topic 1.3.3: Marine water quality	· 1.3.3.g.1: Coral bleaching: Area affected by coral bleaching	
24	Other pollutants		Component 1: Environmental Conditions and Quality, Sub-component 1.3: Environmental Quality, Topic 1.3.3: Marine Water Quality, Topic 1.3.3: Marine water quality		
25	Biophysical conditions Biodiversity Temperature Currents Frequency of storms				

			Component 1: Environmental Conditions and Quality, Sub-component 1.2: Land Cover, Ecosystems and Biodiversity, Topic 1.2.2: Ecosystems and biodiversity	· 1.2.2.c: Biodiversity	FDES would need to develop guidance on specific ocean ecosystems.
			Component 1: Environmental Conditions and Quality, Sub-component 1.3: Environmental Quality, Topic 1.3.3: Marine Water Quality, Topic 1.3.3: Marine water quality	· 1.3.3.f.2: Temperature	
			Component 1: Environmental Conditions and Quality, Sub-component 1.1 Physical Conditions, Topic 1.1.2: Hydrographical characteristics	· 1.1.2.e: Seas	FDES covers physical characteristics but the item is not specified in the statistics. Would be obtained from nautical chart.
			Component 4: Extreme Events and Disasters, Sub-component 4.1: Natural Extreme Events and Disasters, Topic 4.1.1: Occurrence of natural extreme events and disasters	· 4.1.1.a: Occurrence of natural extreme events and disasters	Hurricane and Cyclone scales applicable.

			Component 1: Environmental Conditions and Quality, Sub-component 1.1: Physical Conditions, Topic 1.1.1: Atmosphere, climate and weather	· 1.1.1.e: Wind speed	Monitoring of wind speed over certain thresholds on Beaufort Scale.
26	Sea level		Component 1: Environmental Conditions and Quality, Sub-component 1.1: Physical Conditions, Topic 1.1.2: Hydrographical characteristics	· 1.1.2.e.4: Sea level	
27	Population and infrastructure exposed to natural hazards		Component 4: Extreme Events and Disasters, Sub-component 4.1: Natural Extreme Events and Disasters, Topic 4.1.2: Impact of natural extreme events and disasters	· 4.1.2.a. to 4.1.2.d.	
			Component 5: Human Settlements and Environmental Health, Sub-component 5.1: Human Settlements, Topic 5.1.3: Housing conditions	· 5.1.3.c: Population living in hazard-prone areas · 5.1.3.d: Hazard-prone areas	

	Ocean Services Supply (physical and monetary)	coastal/urban/ rural/high/low income/male/ female			
28	Provisioning: tidal and wave power generation, medium for cultivation, fish production, aquaculture production, other marine organisms		Component 2: Environmental Resources and their Use, Sub-component 2.1: Mineral Resources, Topic 2.1.1: Stocks and changes of mineral resources		
			Component 2: Environmental Resources and their Use, Sub-component 2.2: Energy Resources, Topic 2.2.1: Stocks and changes of energy resources		
			Component 2: Environmental Resources and their Use, Sub-component 2.5: Biological Resources, Topic 2.5.2: Aquatic resources		

29	Regulating and maintenance: receiving discharge, placement of infrastructure, medium for transport, disaster risk reduction		Component 3: Residuals, Sub-component 3.2: Generation and Management of Wastewater, Topic 3.2.3: Discharge of wastewater to the environment	· 3.2.3.a.2: Wastewater discharge: Total volume of wastewater discharged to the environment without treatment	Would need to specify coastal plants.
			Component 4: Extreme Events and Disasters, Sub-component 4.1: Natural Extreme Events and Disasters, Topic 4.1.2: Impact of natural extreme events and disasters		
			Component 5: Human Settlements and Environmental Health, Sub-component 5.1: Human Settlements, Topic 5.1.3: Housing conditions	· 5.1.3.c: Population living in hazard-prone areas · 5.1.3.d: Hazard-prone areas	
30	Cultural				

31	Abiotic: Minerals, energy, medium for transport		Component 2: Environmental Resources and their Use, Sub-component 2.1: Mineral Resources, Topic 2.1.2: Production and trade of minerals		FDES would need to specify production from the Oceans.
			Component 2: Environmental Resources and their Use, Sub-component 2.2: Energy Resources, Topic 2.2.2: Production, trade and consumption of energy		
32	Fishing industry		Component 2: Environmental Resources and their Use, Sub-component 2.5: Biological Resources, Topic 2.5.2: Aquatic resources		
	Ocean Services Use (physical and monetary)				

33	Provisioning: tidal and wave power generation, medium for cultivation, fish production, aquaculture production, other marine organisms		Component 2: Environmental Resources and their Use, Sub-component 2.1: Mineral Resources, Topic 2.1.1: Stocks and changes of mineral resources		
			Component 2: Environmental Resources and their Use, Sub-component 2.2: Energy Resources, Topic 2.2.1: Stocks and changes of energy resources		
			Component 2: Environmental Resources and their Use, Sub-component 2.5: Biological Resources, Topic 2.5.2: Aquatic resources		
34	Regulating and maintenance: receiving discharge, placement of infrastructure, medium for transport, disaster risk reduction		Component 3: Residuals, Sub-component 3.2: Generation and Management of Wastewater, Topic 3.2.3: Discharge of wastewater to the environment	· 3.2.3.a.2: Wastewater discharge: Total volume of wastewater discharged to the environment without treatment	Would need to specify coastal plants.

			Component 4: Extreme Events and Disasters, Sub-component 4.1: Natural Extreme Events and Disasters, Topic 4.1.2: Impact of natural extreme events and disasters		
			Component 5: Human Settlements and Environmental Health, Sub-component 5.1: Human Settlements, Topic 5.1.3: Housing conditions	· 5.1.3.c: Population living in hazard-prone areas · 5.1.3.d: Hazard-prone areas	
35	<u>Cultural</u>				
36	<u>Abiotic:</u> Minerals, energy, medium for transport		Component 2: Environmental Resources and their Use, Sub-component 2.1: Mineral Resources, Topic 2.1.2: Production and trade of minerals		FDES would need to specify production from the Oceans.

			Component 2: Environmental Resources and their Use, Sub-component 2.2: Energy Resources, Topic 2.2.2: Production, trade and consumption of energy		
37	Fishing industry		Component 2: Environmental Resources and their Use, Sub-component 2.5: Biological Resources, Topic 2.5.2: Aquatic resources		
	Governance				
38	Policies for sustainable management				

39	Environmental Protection Expenditures on Oceans		Component 6: Environmental Protection, Management and Engagement, Sub-component 6.1: Environmental Protection and Resource Management Expenditure, Topic 6.1.1: Government environmental protection and resource management expenditure and Topic 6.1.2: Corporate, non-profit institution and household environmental protection and resource management expenditure		
40	Environmental taxes and subsidies		Component 6: Environmental Protection, Management and Engagement, Sub-component 6.1: Environmental Protection and Resource Management Expenditure, Topic 6.2.2 Environmental regulation and instruments	· 6.2.2.b.1: Economic instruments: List and description of green/ environmental taxes · 6.2.2.b.2: List and description of environmentall y relevant subsidies	FDES would need to specify ocean related taxes and subsidies

41	Management practices (including community based)		Component 6: Environmental Protection, Management and Engagement, Sub-component 6.1: Environmental Protection and Resource Management Expenditure, Topic 6.2.2: Environmental regulation and instruments	· 6.2.2.a.2: Direct regulation: Description of licensing system to ensure compliance with environmental standards for businesses or other new facilities · 6.2.2.a.3: Number of applications for licenses received and approved per year · 6.2.2.a.4: List of quotas for biological resource extraction	FDES would need to identify types of regulations. Other types of regulations such as closed seasons to be added. Community based practices to be added.

Appendix 6.5 Ocean-related SDG indicators and links to ocean accounts

- These are the SDG targets and indicators that explicitly mention the ocean, fishers or ecosystems. Other goals would benefit from ocean accounts: SDG1 (No poverty), SDGs 5 and 10 (Gender equality and Reduced inequalities), SDG 8 (Decent work and economic growth), SDG11 (Sustainable cities and communities), SDG12 (Responsible consumption and production), SDG13 (Climate action).

Target	**Indicator**	**Custodian**	**Link to ocean accounts [Subsection in Section 2]**

2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment	2.3.1 Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size	FAO	Ocean services use [2.4] disaggregated by large/ small scale fishing.
	2.3.2 Average income of small-scale food producers, by sex and indigenous status	FAO (with World Bank)	
9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	9.4.1 CO_2 emission per unit of value added	UNIDO, IEA (with UNEP)	Flows to Environment (air emissions) [2.5]; Flows to Economy (Ocean Services) [2.4]; Ocean Economy Satellite Accounts [2.6]
13.2 Integrate climate change measures into national policies, strategies and planning	13.2.1 Number of countries that have communicated the establishment or operationalization of an integrated policy/strategy/ plan which increases their ability to adapt to the adverse impacts of climate change, and foster climate resilience and low greenhouse gas emissions development in a manner that does not threaten food production (including a national adaptation plan, nationally determined contribution, national communication, biennial update report or other)	UNFCCC (with UNEP, WMO, WHO)	Flows to environment (Air Emissions) [2.5]; Ocean Assets (Carbon) [2.3]; Governance [2.7]

14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	14.1.1 Index of coastal eutrophication and floating plastic debris density	UNEP (with IOC-UNESCO, IMO, FAO)	Ocean Assets (Condition) [2.3]; Flows to Environment (Water Emissions, Solid Wastes) [2.5]
14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans	14.2.1 Proportion of national exclusive economic zones managed using ecosystem-based approaches	UNEP (with FAO, UNESCO-IOC)	Ocean Assets (Aquatic Resources, Ecosystem Extent) [2.3]; Governance (Environmental Protection Expenditures) [2.7]; Flows to economy (Ocean Services) [2.4]
14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels	14.3.1 Average marine acidity (pH) measured at agreed suite of representative sampling stations	UNEP (with IOC-UNESCO, FAO)	Flows to environment (Water Emissions) [2.5]; Ocean Assets (Condition, Biodiversity) [2.3]; Governance [2.7]
14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	14.4.1 Proportion of fish stocks within biologically sustainable levels	FAO	Ocean Assets (Aquatic Resources, Ecosystem Extent) [2.3]; Governance (Environmental Protection Expenditures) [2.7]
14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information	14.5.1 Coverage of protected areas in relation to marine areas	UNEP-WCMC, UNEP (with RAMSAR)	Ocean Assets (Aquatic Resources, Ecosystem Extent) [2.3]; Governance (Environmental Protection Expenditures) [2.7]; Flows to Economy (Ocean services) [2.4]

14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation[3]	14.6.1 Progress by countries in the degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing	FAO	Ocean Assets (Aquatic Resources, Ecosystem Extent) [2.3]; Governance (Environmental Protection Expenditures) [2.7]
14.7 By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism	14.7.1 Sustainable fisheries as a proportion of GDP in small island developing States, least developed countries and all countries	FAO, UNEP-WCMC	Ocean Assets (Aquatic Resources, Ecosystem Extent) [2.3]; Governance (Environmental Protection Expenditures) [2.7]
14.a Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries	14.a.1 Proportion of total research budget allocated to research in the field of marine technology	IOC-UNESCO (with UNEP)	Governance (Environmental Protection Expenditures, Environmental Goods and Services Sector) [2.7]

14.b Provide access for small-scale artisanal fishers to marine resources and markets	14.b.1 Progress by countries in the degree of application of a legal/ regulatory/ policy/ institutional framework which recognizes and protects access rights for small-scale fisheries	FAO	Governance (Environmental Protection Expenditure Accounts) [2.7]
14.c Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of "The future we want"	14.c.1 Number of countries making progress in ratifying, accepting and implementing through legal, policy and institutional frameworks, ocean-related instruments that implement international law, as reflected in the United Nations Convention on the Law of the Sea, for the conservation and sustainable use of the oceans and their resources	UN-DOALOS, FAO, UNEP, ILO, other UN Oceans agencies	Governance (Environmental Protection Expenditure Accounts) [2.7]
15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	15.5.1 Red List Index	IUCN (with UNEP, CITES)	Ocean Assets (Ecosystem Condition, Biodiversity) [2.3]
15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts	15.9.1 Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020	CBD-Secretariat, UNEP	Governance [2.7]

Appendix 6.6 Examples of characteristic ocean economic activities.

Note: **Tables 38** and **39** are sources for **Table 40**, which is summarized in the main text in **Table 14**.

Table 38. Ocean-related ISIC codes. Adapted from Wang, 2016.

Sector	**ISIC Code**	**Description**	**Ocean share**

Fishing/aquaculture	0311	Marine fishing	Full
	0321	Marine aquaculture	Full
	1020	Processing and preserving of fish, crustaceans and molluscs	Full
Offshore oil and gas	0610	Extraction of crude petroleum	Partial
	0620	Extraction of natural gas	Partial
	0910	Support activities for petroleum and natural gas extraction	Partial
Boat and Ship Building, Maintenance and Repair	3011	Building of ships and floating structures	Full
	3012	Building of pleasure and sporting boats	Full
	3315	Repair of transport equipment, except motor vehicles	Partial
Marine renewable energy and distribution	3510	Electric power generation, transmission	Partial
Marine construction	4290	Construction of other civil engineering projects	Partial
	4311	Demolition	Partial
	4312	Site preparation	Partial
	4321	Electrical installation	Partial
	4322	Plumbing, heat and air-conditioning installation	Partial

	4329	Other construction installation	Partial
	4390	Other specialized construction activities	Partial
Marine transportation	5011	Sea and coastal passenger water transport	Full
	5012	Sea and coastal freight water transport	Full
	5210	Warehousing and storage	Partial
	5222	Service activities incidental to water transportation	Partial
	5224	Cargo handling	Partial
	5229	Other transportation support activities	Partial
	4930	Transport via pipeline	Partial
Marine tourism	5510	Short term accommodation activities	Partial
	5520	Camping grounds, recreational vehicle parks and trailer parks	Partial
	5590	Other accommodation	Partial
	5610	Restaurants and mobile food service activities	Partial
	5621	Event catering	Partial
	5629	Other food service activities	Partial

	5630	Beverage serving activities	Partial
	7911	Travel agency activities	Partial
	7912	Tour operator activities	Partial
	7990	Other reservation service and related activities	Partial
	9102	Museums activities and operation of historical sites and buildings	Partial
	9103	Botanical and zoological gardens and nature reserves activities	Partial
	9312	Activities of sports clubs	Partial
	9321	Other sports activities	Partial
	9329	Other amusement and recreation activities n.e.c.	Partial
Marine research and education	7210	Research and experimental development on natural sciences and engineering	Partial
	8521	General secondary education	Partial
	8522	Technical and vocational secondary education	Partial
	8530	Higher education	Partial
	8541	Sports and physical education	Partial
	8549	Other education n.e.c.	Partial

- **Table 39** below shows the industries that have been identified as part of the "ocean economy" by 25 nations and international organisations in either their current statistical systems or in their "blue economy" or similar plans. The table also shows the percentage of mentions for that industry across all the reports examined. The names of the industries represent combinations of similarly designated industries.

Table 39. Illustrative characteristic industries of the ocean economy (% of times mentioned; n=25). Source: Colgan (2018).

Commercial fishing (96%)	Marine Electric Power Industry (72%)	Ocean-related Services (32%)	Petroleum Oriented Supply Industry (8%)	LPG Processing (4%)
Offshore oil and gas (92%)	Marine environmental protection (60%)	Marine equipment industry (32%)	Marine Equipment Retailing (8%)	Boat Building (4%)
Coastal tourism (92%)	Marine Biomedicine Industry (56%)	Marine Salt Industry (28%)	Ports (8%)	Recreational Fishing (4%)
Marine transportation (92%)	Marine Environment Monitoring and Prediction (60%)	Marine Geologic Exploration (24%)	Search and Navigation Equipment (8%)	Transport Services (4%)
Shipbuilding industry (84%)	Marine Education (52%)	Marine Agriculture, Forestry Industry (20%)	Marine Chemical Industry (8%)	Biotechnology (4%)
Marine engineering (84%)	Marine Insurance (40%)	Marine Construction (16%)	Marine social and international organizations (8%)	Government (4%)
Marine science research (80%)	Marine Technology Services (40%)	Extraction of Aggregates (12%)	Marine/ Environmental Consulting (8%)	Waste Management Services (4%)
Ocean mining industry (76%)	Marine Information Services (36%)	Cruise Tourism (12%)	Ocean-related materials (8%)	Surveying and Mapping (4%)
Marine Management/Pub Admin/Defense (76%)	Seafood processing (32%)	Marine Wholesale and Retail Industry (12%)	Seabed Mining (4%)	Renewable Energy (1%)

Aquaculture (72%)	Seawater Utilization Industry (32%)	Seafood Supply (8%)	Refineries (4%)	Cordage (1%)

Table 40. Ocean-related ISIC codes (expanded with Colgan, 2018). Note: Activities included in Colgan not classified here due to generality include Marine technology services, Ocean-related services, Ocean-related materials, Biotechnology.

Sector	ISIC Code	Description	Ocean share	Notes
Ocean-related hunting (walrus,seals)	0170	Hunting, trapping and related service activities	Partial	Includes land-based catching of sea mammals such as walrus and seal
Fishing/ aquaculture	0311	Marine fishing	Full	Includes gathering of other marine organisms and materials: natural pearls, sponges, coral and algae; presume also biomedicines; recreational and subsistence fishing
	0321	Marine aquaculture	Full	
Offshore oil and gas	0610	Extraction of crude petroleum	Partial	
	0620	Extraction of natural gas	Partial	
Marine mining and quarrying	0810	Quarrying of stone, sand and clay	Partial	
	0890	Mining and quarrying n.e.c.	Partial	Includes polymetallic nodules?
	0893	Extraction of salt	Full	

Mining support service activities	0910	Support activities for petroleum and natural gas extraction	Partial	
	0990	Support activities for other mining and quarrying	Partial	
Marine manufacturing	1020	Processing and preserving of fish, crustaceans and mollusks	Full	
	1394	Manufacture of cordage, rope, twine and netting	Partial	Includes fish nets?
Marine chemical industry	2011	Manufacture of basic chemicals	Partial	Marine chemicals could also be included in other chemical products
	2029	Manufacture of other chemical products n.e.c.	Partial	Marine chemicals could also be included in other chemical products
	2100	Manufacture of pharmaceuticals, medicinal chemical and botanical products	Partial	Includes marine biomedicines?
Boat and Ship Building, Maintenance and Repair	3011	Building of ships and floating structures	Partial	Was full
	3012	Building of pleasure and sporting boats	Partial	Was full
Repair and installation of marine equipment	3315	Repair of transport equipment, except motor vehicles	Partial	

Marine renewable energy and distribution	3510	Electric power generation, transmission and distribution	Partial	
Salt water supply	3600	Water collection, treatment and supply	Partial	Desalination and water for cooling
Waste management services	3700	Sewerage	Partial	Dumping wastewater to sea
Marine construction	4290	Construction of other civil engineering projects	Partial	Includes ports, harbours
	4311	Demolition	Partial	
	4312	Site preparation	Partial	
	4321	Electrical installation	Partial	
	4322	Plumbing, heat and air-conditioning installation	Partial	
	4329	Other construction installation	Partial	
	4390	Other specialized construction activities	Partial	Includes ports, harbours
Marine equipment wholesale	4659	Wholesale of other machinery and equipment	Partial	Includes wholesale of other machinery n.e.c. for use in industry, trade and navigation and other services

Marine equipment retail	4773	Other retail sale of new goods in specialized stores	Partial	Includes retail sale of photographic, optical and precision equipment
Transport via marine pipeline	4930	Transport via pipeline	Partial	
Marine transportation	5011	Sea and coastal passenger water transport	Full	
	5012	Sea and coastal freight water transport	Full	
Warehousing and support activities for transportation	5210	Warehousing and storage	Partial	
	5222	Service activities incidental to water transportation	Partial	
	5224	Cargo handling	Partial	
	5229	Other transportation support activities	Partial	
Marine tourism	5510	Short term accommodation activities	Partial	
	5520	Camping grounds, recreational vehicle parks and trailer parks	Partial	
	5590	Other accommodation	Partial	
Food and beverage service activities	5610	Restaurants and mobile food service activities	Partial	

	5621	Event catering	Partial	
	5629	Other food service activities	Partial	
	5630	Beverage serving activities	Partial	
Marine information services	6311	Data processing, hosting and related activities	Partial	Could include other information services
Marine insurance	6512	Non-life insurance	Partial	Includes marine insurance
Marine geologic exploration	7110	Architectural and engineering activities and related technical consultancy	Partial	Includes geophysical, geologic and seismic surveying; geodetic surveying activities:
Marine research and education	7210	Research and experimental development on natural sciences and engineering	Partial	
Marine/ Environmental Consulting	7490	Other professional, scientific and technical activities n.e.c.	Partial	
Travel agency, tour operator, reservation service and related activities	7911	Travel agency activities	Partial	
	7912	Tour operator activities	Partial	
	7990	Other reservation service and related activities	Partial	

Ports (maintenance)	8130	Landscape care and maintenance service activities	Partial	Includes ports, harbours
Public adminstration and defence	8411	General public administration	Partial	Includes marine management, environmental monitoring and protection, public administration; National and local government, and NGO specific activities
	8422	Defence activities	Partial	Coastal activities
Education	8521	General secondary education	Partial	Why?
	8522	Technical and vocational secondary education	Partial	Why?
	8530	Higher education	Partial	
	8541	Sports and physical education	Partial	
	8549	Other education n.e.c.	Partial	
Libraries, archives, museums and other cultural activities	9102	Museums activities and operation of historical sites and buildings	Partial	
	9103	Botanical and zoological gardens and nature reserves activities	Partial	

Sports activities and amusement and recreation activities	9312	Activities of sports clubs	Partial	
	9321	Other sports activities	Partial	
	9329	Other amusement and recreation activities n.e.c.	Partial	

Table 41. Components of the "Blue Economy". Source: World Bank and United Nations Department of Social and Economic Affairs, 2017.

Type of Activity	Activity Subcategories	Related Industries/ Sectors	Drivers of Growth
Harvesting and trade of marine living resources	Seafood harvesting	Fisheries (primary fish production)	Demand for food and nutrition, especially protein
		Secondary fisheries and related activities (e.g., processing, net and gear making, ice production and supply, boat construction and maintenance, manufacturing of fish-processing equipment, packaging, marketing and distribution)	Demand for food and nutrition, especially protein
		Trade of seafood products	Demand for food and nutrition, especially protein
		Trade of non-edible seafood products	Demand for cosmetic, pet, and pharmaceutical products
		Aquaculture	Demand for food and nutrition, especially protein
	Use of marine living resources for pharmaceutical products and chemical applications	Marine biotechnology and bioprospecting	R&D and usage for health care, cosmetic, enzyme, nutraceutical, and other industries
Extraction and use of marine non-living resources (non-renewable)	Extraction of minerals	(Seabed) mining	Demand for minerals
	Extraction of energy sources	Oil and gas	Demand for (alternative) energy sources
	Freshwater generation	Desalination	Demand for freshwater
Use of renewable non-exhaustible natural forces (wind, wave, and tidal energy)	Generation of (off-shore) renewable energy	Renewables	Demand for (alternative) energy sources

Type of Activity	Activity Subcategories	Related Industries/ Sectors	Drivers of Growth
Commerce and trade in and around the oceans	Transport and trade	Shipping and shipbuilding	
		Maritime transport	Growth in seaborne trade; transport demand; international regulations; maritime transport industries (shipbuilding, scrapping, registration, seafaring, port operations, etc.)
		Ports and related services	
	Coastal development	National planning ministries and departments, private sector	Coastal urbanization, national regulations
	Tourism and recreation	National tourism authorities, private sector, other relevant sectors	Global growth of tourism
Indirect contribution to economic activities and environments	Carbon sequestration	Blue carbon	Climate mitigation
	Coastal Protection	Habitat protection, restoration	Resilient growth
	Waste Disposal for land-based industry	Assimilation of nutrients, solid waste	Wastewater Management
	Existence of biodiversity	Protection of species, habitats	Conservation

Appendix 6.7 CMECS and CBiCS ecosystem classification systems

- The CMECS and CBiCS are recommended for testing and comparison with the IUCN Global Ecosystem Typology (GET).
- United States' **Coastal and Marine Ecological Classification System** **(CMECS)**: classifies CMECS classifies the environment into biogeographic and aquatic settings that are differentiated by features influencing the distribution of organisms, and by salinity, tidal zone, and proximity to the coast. Within these systems are four underlying components that describe different aspects of the seascape. These components provide a structured way to organize information and a standard terminology. The components can be mapped independently or combined as needed, as illustrated in **Figure 25** below.

Figure 25 Structure and components of CMECS classification scheme

Figure 25. Structure and components of CMECS classification scheme.

- ESCAP is testing the CMECS for applicability to the ocean accounts. Meanwhile, other classification schemes are also being reviewed.
- **Combined Biotope Classification Scheme (CbiCS):** adapts components from the Joint Nature Conservation Committee – European Nature Information System (JNCC-EUNIS) and the CMECS. It provides a unified scheme for classifying all marine habitats and biotopes and is consistent with the terrestrial classification of vegetation biotopes and biotope complexes (e.g. Ecological Vegetation Classes (EVCs)). CbiCS is a hierarchical scheme that enables the incorporation of a variety of information sources of disparate types and levels of resolution. The hierarchical components used to formulate the biotope classification of CbiCS (left), and the hierarchical components of the biotic component (right), are illustrated in Figure 26 below.

Figure 26 Hierarchical components of CBiCs classification scheme and Biotic Component hierarchy

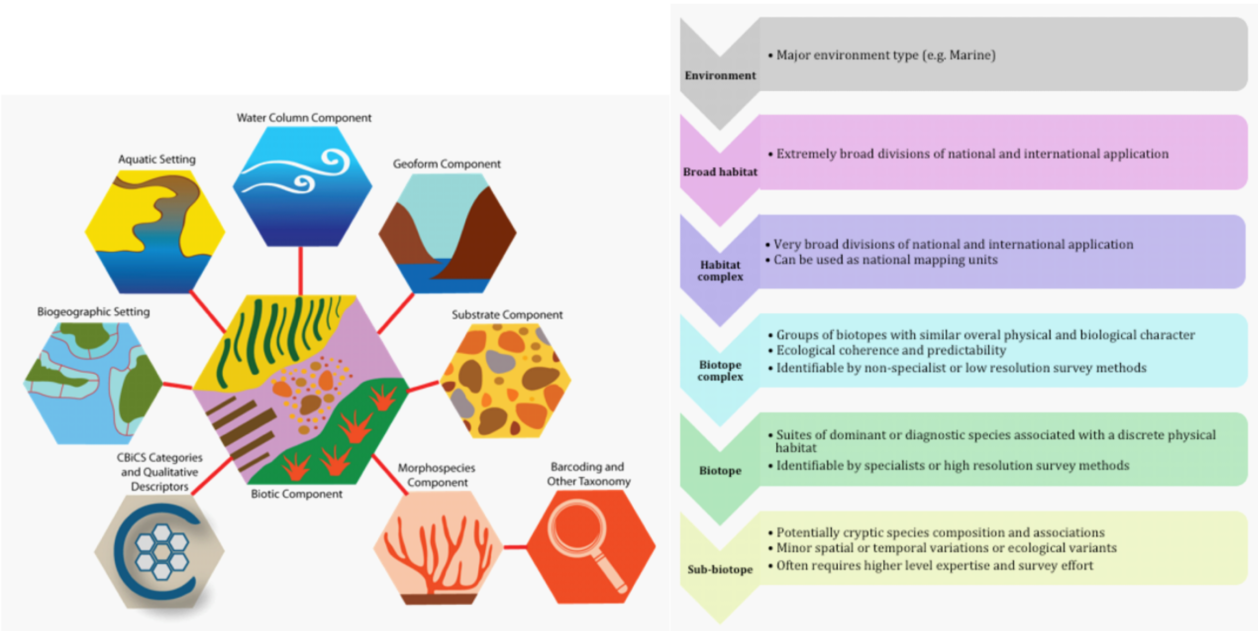

Figure 26. Hierarchical components of CBiCs classification scheme and Biotic Component hierarchy.

Appendix 6.8 Additional research questions.

- This section describes in more detail the areas in which more work is required, in particular specific outstanding research questions related to the geospatial foundations of ocean accounting; ecosystem condition and services; valuation of ocean assets and services; use cases for Ocean Accounts; enabling factors for ocean accounting; and tools and methods for ocean accounting. The questions listed below represent a synthesis of submissions to date from the authors of this Guidance.

6.8.1 Geospatial foundations of Ocean Accounts

- What is the necessary minimum scale for analysis in the accounting system (how does this intersect with needs for decisionmakers and researchers)?
- What is the best way to represent/deal with the depth profile of the ocean from a geospatial perspective (and how to associate the indicators/metrics in the accounting system with depth)?

6.8.2 Ecosystem condition and services

- What are the key, initial, bare minimum set of ecosystem condition measures that should be evaluated at a global level for the oceans?
- Similarly, what are the key, priority ecosystem services for the oceans that should be evaluated at a global level in the accounting system?
- What are the potential relationships between prioritized condition measures and prioritized ecosystem services (not to do actual analysis, but to ensure we are collecting relevant matching “sets” so that analyses can be done?)
- How do we represent areas of supply and demand for ecosystem services – for example, is it where fish are caught, who catches them, where they are landed, where they primarily feed, where they nurse, or some weighted combination?

- The UN must work together with interested Member States National Statistics Offices, data producers (of all types), data managers, infrastructure experts, algorithm developers, and application providers to support the development of a geo-spatial platform for implementing Ocean Accounts.
- This platform should take into consideration the principles highlighted within the UN Environment concept paper for a Digital Ecosystem for the Environment and GEO's Knowledge Hub in order to provide actionable evidence and maximise ownership, participation, co-design and reusability of the solution.
- There are a number of ongoing initiatives in the ocean and Earth observation domain which are related to the geospatial foundations of ocean accounting. While these are not exclusively research and development initiatives, there is an opportunity to join efforts in order to work on areas which can benefit the understanding of how best we can apply new concepts in geospatial infrastructures, Artificial Intelligence/ Machine Learning and Interoperability to Ocean Accounting.
- How valuable can Artificial Intelligence and Machine Learning be for Ocean Accounting? How can we specifically combine cloud technology, Artificial Intelligence and data science to address our objectives and develop a set of Ocean Accounting products?
- There are multiple programs which are providing opportunities to study how best to bring together the vast amount of Earth observation data with advances in technology (storage, discovery and analysis). There is nevertheless a gap in the application of this new technology to the ocean domain. There is therefore an opportunity to engage with these programs (at both research and operational level) to develop specific geospatial solutions for Ocean Accounting. In addition to what described in Section 4, some (non-exhaustive) examples include:
- AI for Earth: This initiative aims at making access to powerful Artificial Intelligence and Machine Learning technology more practical for scientists and environmental researchers. In doing this, the initiative also supports users in making large datasets ready for AI for processing as well as assists in the development of AI and Machine Learning algorithms.
- REV Ocean: In recognising that data-driven innovation and research for the marine domain is far behind the one done for land applications, the Ocean Data Platform is an initiative to establish a global, unifying ocean data platform to enable unbiased research and facilitate a data-driven debate, leading to better decision-making and enable more successful conservation and utilization of ocean resources. The objectives of the data platform are to: 1) Contribute to data liberation from source systems and remove proprietary silos; 2) Contextualize the data in a common format to enable cross-domain analytics and visualizations, and; 3) Make data available through open, high performing and well documented APIs to make it as easy as possible to access and build applications.
- Earth on AWS:[3] In collaboration with GEO, this initiative provides free credits to projects using Earth observation datasets to support environmental and development goals. The cloud services include the hosting, processing and analysis of large geospatial data sets for non-commercial purposes, prioritizing projects that make use of open satellite data.
- Data Cubes: The value of Earth observation satellite data is still underutilised despite modern computing and analysis infrastructures. Data Cubes provide a solution to streamline data distribution and management for providers while simultaneously lowering the technical barriers for users to exploit the data to its full potential. While many Data Cubes are being developed with the objective of providing solutions for land-based applications, there is a need to further advance the application of this concept to the ocean domain. This thematic could be further analysed together with the Open Data Cube project and its partners.
- Open SDG Data Hub: As for Ocean Accounting purposes, to fully implement and monitor progress on the Sustainable Development Goals, data and statistics needs to be accurate, timely, sufficiently disaggregated, relevant, accessible and easy to use. The Open SDG Data Hub promotes the exploration, analysis, and use of authoritative SDG data sources and provides an interface to retrieve data at national level through an open interface. How can the Ocean Accounting community take stock of this to discover, understand, share and communicate data products?
- Ultimately, it is important to focus research and development activities on how we can build an Ocean Accounting geo-spatial platform, which can integrate different types of Earth Observation data (e.g. remote sensing, to in-situ, to modelling), with other economic and social science datasets (e.g. from fish catches to vessel traffic information), from various sources (e.g. from satellite, to national census, to citizen science),

make use of cloud technologies to ease and rationalise discoverability, access and use and, exploit advances in Artificial Intelligence/Machine Learning algorithms and techniques to analyse and process the datasets?

6.8.3 Valuation of ocean assets and services

- What are the recommended approaches for valuing assets and services that can be done on a global level?
- Along these lines, how can we make use of better benefit transfer and meta-analyses to be able to fill gaps in valuation so that we have a reliable global dataset?
- Which are the beneficiary groups that we should focus on for valuation in the accounting system (e.g., extractors, consumers, non-consumptive users)?
- How do we account for the impact of subsidies and management systems on values of assets and services if try to create a global estimate?

6.8.4 Use cases for Ocean Accounts

- How should practical use cases for ocean accounts be classified, for the purposes of compiling a coherent and modular set of case studies, and more broadly?
- What specific types of government decisions about oceans can be informed by ocean accounts, and how?
- How can ocean accounts support the compilation of indicators and other reporting information supporting implementation of the 2030 Agenda for Sustainable Development and Sustainable Development Goal (SDG) indicators?
- How can ocean accounts support the development, monitoring and assessment of nationally determined contributions and other commitments under the Paris Agreement on Climate Change?
- How can ocean accounts support the design and implementation of marine spatial planning and integrated coastal zone management?
- How can ocean accounts support the design and implementation of national strategies for ocean-based economic development, including sector specific development strategies (fisheries, tourism, etc)?

6.8.5 Enabling factors for ocean accounting

- The UN Decade of Ocean Science for Sustainable Development (https://en.unesco.org/ocean-decade) provides an important opportunity to build on the current interest, need for and momentum for Ocean Accounting. An effort has to be undertaken to include Ocean Accounting within the priorities of the UN Decade, as the investments made towards the implementation of such a framework will also benefit and further enable the establishment of solid methodologies for the monitoring and reporting of SDG-14 indicators.
- One of the most critical enabling factors for the implementation of the Ocean Accounting framework is Capacity Building. Access to geo-spatial platforms, large volumes of Earth observation, economic and social science data, innovative use of Artificial Intelligence and Machine Learning algorithms and techniques will be ineffective should these stakeholders not be proficient with the basic tools.
- This Guidance document should therefore also serve as platform to understand the capacity building needs of Member States and their National Statistic Offices. From science, to data access management, to technological tools and methods, the process initiated by this document should be seen as a vehicle for the definition of a capacity building plan for Ocean Accounting needs within Member States.

6.8.6 Tools and methods

- It is essential for the Ocean Accounting community to recognise the important role social sciences can offer in management and decision making for our global seas and coasts.
- Marine Social Science must be considered an important, integral and substantial contribution for understanding the human dimension of ocean and coastal policy for any government agency (Bennet, 2019). Marine Social Science offers insights for the planning and decision making of ocean-focussed policies at

local, national and global level, from documenting the social context, to assessing the impacts of ocean related conservation/management/development activities on humans. It is therefore important to assess how the Ocean Accounting framework can include marine social science in its process.

- What is the relevance of each Ecosystem Biodiversity Variables and Essential Ocean Variables for Ocean Accounting purposes? What is the weight of each parameter and how critical are these variables? There is a need to evaluate in detail the different classes of parameters, their availability at national, regional and global level, and how these can be integrated within the overall Ocean Accounting framework.
- How can we apply disruptive technology, entrepreneurship, and open innovation to develop new tools and methods for Ocean Accounting purposes? How can we create an environment where science, technology, social science, and government (NSO) communities come together to co-create tech-enabled solutions for Ocean Accounting?

Appendix 6.9 Description of “stressors” and how they fit into the ocean accounts framework.

- This appendix provides additional descriptions of several concepts that are used in the set of Core Ocean Statistics (see Core Ocean Statistics).

1. Sea Level Rise is considered a *change in condition* in the Condition Accounts. It is driven primarily by thermal expansion of seawater and, to a lesser degree, melting of ice in the polar oceans. It could cause changes in *ecosystem extent* (e.g., coastal settlements, infrastructure, beaches, wetlands, mangroves), changes in services (e.g., coastal protection, filtration, amenity value) if it occurs over extended periods (Nichols and Cazenave, 2010).
2. Ocean Warming is also a *change in condition*. It is an increase in sea surface temperature (SST) due to increased accumulation of greenhouse gasses (CO_2, CH_4, N_2O) in the atmosphere, thereby trapping in heat and warming the land and surface oceans. Ocean warming can impact other *conditions*, such as organism metabolic rates and resulting oxygen availability, storm frequency, mean sea level (see Sea level rise above), rainfall patterns, and most notably long-term changes in thermohaline circulation. Such conditions are usually tracked in more detail in other frameworks (e.g., IPCC; Clarke et al., 2013).
3. Eutrophication (i.e., elevated organic matter concentration) is a *condition* characterised by excess concentrations of particulate and dissolved organic matter. Abnormally high concentrations of organic matter are created by the rapid bloom and die-off of plankton populations, generally stimulated by excess dissolved inorganic nutrients. These nutrients may come from terrestrial runoff events (flows from the economy to the environment), deep-water upwelling events, or the over-retention of locally produced nutrients due a reduction in seawater mixing (e.g., stagnation) (Bell, 1992; Menzel et al., 2013).
4. Ocean Acidification (i.e., low pH, reduced calcification, and dissolution of calcium carbonate) is a *condition* caused by increased sequestration of atmospheric CO_2 into the surface oceans and is of primary concern in environments where a large part of the benthic sessile community conducts calcification (e.g., coral reefs). Acidification may also happen in coastal locations (Coastal Acidification) due to a biological reduction in seawater pH due to eutrophication (remineralization of dead plankton) (Kleypas et al. 2001; Hofmann et al., 2011).
5. Hypoxia/Anoxia (i.e., low to no dissolved oxygen) is a *condition* that leads to widespread die off of the local fauna and can be caused by differing processes such as eutrophication, changes in the physical oceanography, seawater warming, or drought (Chan et al., 2008; Barbier et al., 2011).
6. Pollutants (residuals, plastics, nutrients, sediments, solid waste, marine litter etc.) are both *flows from the economy to the environment* and *conditions*. Measures of the flows (loads, in tonnes) provide insight into the reasons for *changes* in condition. *Condition* measures are usually in terms of concentrations in the water, substrate and biota. To provide useful condition indicators, the measures should be indexed to a reference condition, such as “natural” or “suitable for wildlife”.
7. Overfishing is an *assessment of the degradation of ocean assets.* It is caused by more fish being harvested than the natural regeneration rate. Fish stocks by species are recorded in the Asset Accounts as “individual environmental assets”. Fish harvesting is recorded as a *flow from the environment to the economy* and as a

provisioning service. Fish harvest is indicated in the *Ocean Asset Accounts* as *a reason for reduction in stocks*. Natural regeneration is recorded as a *natural increase in stocks*. If reductions exceed regeneration or replenishment, an assessment would need to be made if this is "overfishing" by comparison to an established Maximum Sustainable Yield (MSY) and other explanatory factors (e.g., change in temperature, fishing effort, increase in predator populations) (Steneck et al., 2002; Cesar et al., 2003; Halpern et al., 2006) .

8. Habitat Loss results from conversion of an ecosystem from one type to another. This is recorded as *changes in extent* in the *Extent Accounts*. Loss of habitat may occur in response to the 7 stressors above but may also occur due to other reasons (e.g., coastal development or disease). It may also be caused by extreme changes in *condition* (e.g., disturbance by humans or unsuitable levels of pollutants). This would be recorded in the *Condition Accounts* if it occurs over several accounting periods. Habitat locations are often determined using models based on *conditions* that are typical for a specific species. As such, "habitats" are generally much more localized than ecosystem types. Changes in *extent* may result in further changes in *conditions* (e.g., reduction in biodiversity) and ecosystem services (e.g., maintenance of chemical conditions of water) (Barbier et al., 2011).

Appendix 6.10 Core ocean statistics for key ecosystem types

Table 42. Coral Reef ecosystem core statistics

Ecosystem Type: Coral Reefs	
Category	**Statistic**
Ocean Assets	
Condition	*Overall condition statistics*
Biodiversity	Coral coverage (satellite data)
	Hermatypic coral abundance (in-situ)
	Hermatypic coral diversity (in-situ)
Ecosystem Fitness	Production: Respiration Ratio
	Net Accretion Rate
	Total Alkalinity/DIC Slope
	Reef water flow velocity
Biogeochemical Cycling	Nitrate concentration

	Total Alkalinity
	Offshore: Inshore DIC ratio
	Aragonite Saturation State
	Dissolved Oxygen
	pH (total scale)
Physiochemical Quality	Temperature
	Mean Sea Level
	Salinity
Greenhouse Gas Retention	Dissolved Inorganic Nutrient Concentration
	Carbon Dioxide Flux
	Coral coverage (satellite data)
	Sediment: Hard Coral Ratio
Stock	*Overall stock statistics*
Ecosystem Extent	Coral coverage (satellite data)
	Total reef area (satellite data)
Stock of Natural Aquatic Resources	Stocks of Subsistence Fish
(Vertebrates)	Stocks of Recreational Fish
	Stocks of Commercial Fish
	Stocks of Ornamental Aquarium Fish
Stock of Natural Aquatic Resources	Stocks of Echinoderms

(Invertebrates, Algae, Plants)	Stocks of Gastropods
	Stocks of Ornamental Aquarium Coral for Export
	Stocks of Bivalves
Stock of Cultivated Aquatic Resources	Gross Pelagic Fish Reared
(Vertebrates)	Gross Reef Fish Reared
Stock of Cultivated Aquatic Resources	Gross Coral Cultured
(Invertebrates)	Gross Algae Grown
Stock of Abiotic Resources	Calcium Available for Harvest
	Minerals/Oils Available for Extraction
Ocean Services	
Regulating	*Conditions affecting flow of service*
Greenhouse Gas Sequestration	Coastal geomorphology
	Sediment deposition rate
	Light availability
	Coral Cover
Coastal Protection	Coral Species
	Reef length/distance
	Water depth
	Mean Wave Height
	Storm Frequency

Erosion Control	Sea Level Rise Rate
	Terrestrial Sediment Deposition Rate
	Reef slope to lagoon sediment deposition rate
Water Purification	Sediment Organic Carbon:Nitrogen Ratio
	Benthic coral:algae cover ratio
Nutrient Cycling	Benthic algae cover
	Sediment cover
	Ratio of Nitrate:Ammonium
Waste Remediation	Sediment Organic Carbon Content
	Sediment Organic Nitrogen Content
	Plastic Pollutant Load
	Terrestrial Runoff Rate
Pollutant Remediation	Fertilizer Concentrations
	POC/PON Concentrations
	Ciguatera Presence
Provisioning	*Conditions affecting flow of services/economic values*
Maintenance of Fisheries	Fish catch and value
	Coral Cover
Cultivated Resources Extracted	Value of Cultivated Vertebrates
	Value of Cultivated Invertebrates

Raw Materials Extracted	Value of Coral Sand Extracted
	Value of Guano Extracted
Cultural	*Service levels and values*
Tourism/Recreation	Swimmable Area (Lagoon Size)
	Underwater Tourism
	Nautical Tourism
	Surfing/Recreational Tourism
Education/Research	Net Expense on Research
	Net Expense on Education
Religious/Spiritual/Indigenous	Cultural Heritage Area
Ocean Governance	*Activities, status, expenditures and value statistics*
Regulation	License Fees/Taxes
	Taxes on Cultivated Resources
	Taxes on Natural Resources
Enforcement	Permit Income
	Penalties/Fines
Restoration/Conservation	Area Conserved (no take)
	Area Conserved (recreational take only)
	Biomass Restocked (vertebrates)
	Biomass Restocked (invertebrates)

Mitigation	Length of Engineered Coastal Barriers
	Area Geoengineered
Gross value added by sector	Gross value added of all Ocean Services by sector
Expenditure	Expenditures on environmental protection and maintenance

Table 43. Mangrove ecosystem core statistics

Ecosystem Type: Mangroves	
Category	**Statistic**
Ocean Assets	
Condition	*Overall condition statistics*
Biodiversity	Enhanced Vegetation Index (MODIS Imaging)
	Percent Tree Cover (MODIS Imaging)
	Phytoplankton Abundance/Diversity
Ecosystem Fitness	Percent Tree Cover
	Leaf Area Index
	Chlorophyll Absorption (Hyperspectral Imaging)
	Soil Carbon
Biogeochemical Cycling	Soil Nitrogen
	Turbidity
	Sediment Accumulation:Sea Level Rise

	Particulate/Dissolved Organic C:N
	Dissolved Oxygen
	Soil and Water pH
Physiochemical Quality	Mean Sea Level
	Tidal Regime
	Salinity
Greenhouse Gas Retention	Methane Flux
	Carbon Dioxide Flux
	Sedimentation Rate (Mud Content)
	Canopy Area Cover (Landsat Images)
Stock	*Overall stock statistics*
Ecosystem Extent	Percent Tree Cover (MODIS Imaging)
	Total Mangrove Area (satellite imaging)
Stock of Natural Aquatic Resources	Stocks of planktivorous fish
(Vertebrates)	Stocks of piscivorous fish
	Bird abundance/diversity
Stock of Natural Aquatic Resources	Gross Mangrove Removal
(Invertebrates)	Macrobenthic Community (Sponges, polychaetes)
Stock of Cultivated Aquatic Resources	Gross Piscivorous Fish Grown
(Vertebrates)	Gross Planktivorous Fish Grown

Stock of Cultivated Aquatic Resources	Oyster Aquaculture
(Invertebrates)	Shrimp Aquaculture
Stock of Abiotic Resources	Charcoal Available for Harvest
	Fuelwood Available for Harvest
Ocean Services (Flows to the Economy)	
Regulating	*Conditions affecting flow of service*
Greenhouse Gas Sequestration	Coastal geomorphology
	Sediment deposition rate
	Vegetation Type/Density
Coastal Protection	Sediment Elevation Rate
	Mangrove Mean Age
	Mean Sea Level
	Tidal Height
	Geomorphic Settings
Erosion Control	Distance to Human Settlement
	Sea level rise
	Vegetation Type/Density
Water Purification	Mangrove Cover/Distance
	Sediment Quality
Nutrient Cycling	Nitrification Rate

	Biological Oxygen Demand
	Sulfate Reduction Rate
Waste Remediation	Mangrove quality and area
	Mangrove Root Length (aerial exposure)
	Adjacent Farming Development
	Shrimp Pond Development
Pollutant Remediation	Fertilizer Concentrations
	Dissolved Nutrient Concentrations
	Trace Metal Concentrations
Provisioning	*Conditions affecting flow of service/economic values*
Maintenance of Fisheries	Fish Catch and value
	Time Spent Fishing
	Shrimp/Shrimp Fry Caught
Cultivated Resources Extracted	Value of Cultivated Vertebrates
	Value of Cultivated Invertebrates
Raw Materials Extracted	Fuelwood Harvested and Value
	Charcoal Harvested and Value
Cultural	Service levels and values
Tourism/Recreation	Mangrove Area/Lagoon Size
	Distance to Human Settlement

	Tourism Generated Income
	Recreation Generated Income
Education/Research	Net Expense on Research
	Net Expense on Education
	Education Level
Religious/Spiritual/Indigenous	Cultural Heritage Area
Ocean Governance	*Activities, status, expenditures and value statistics*
Regulation	License Fees/Taxes
	Taxes on Cultivated Resources
	Taxes on Natural Resources
Enforcement	Permit Income
	Penalties/Fines
Restoration/Conservation	Area Conserved (no take)
	Distance to Industry/Ports
	Biomass Restocked
	Post-restoration care
Mitigation	Length of Engineered Coastal Barriers
	Area Geoengineered
Gross value added by sector	Gross value added of all Ocean Services by sector
Expenditure	Expenditures on environmental protection and maintenance

Table 44. Kelp Forest ecosystem core statistics

Ecosystem Type: Kelp Forest	
Category	**Statistic**
Ocean Assets	
Condition	Overall condition statistics
Biodiversity	Macroalgae Species Richness
	Kelp Canopy Biomass (in-situ)
	Benthic Macroinvertebrate Diversity
Ecosystem Fitness	Availability of Drift Algae
	Turf Algae Abundance
	Urchin Grazing Intensity
	Ratio of Invasive: Natural kelp species
	Juvenile Kelp Recruitment Rate
Biogeochemical Cycling	Nitrate Concentration
	Ammonium Concentration
	Kelp Growth Rate
	Dissolved Oxygen Concentration
	C13 Stable Isotopes
	N15 Stable Isotopes
Physiochemical Quality	Temperature

	Light availability
	Salinity
Greenhouse Gas Retention	Light availability
	Carbon Storage
	Kelp Forest Biomass
Stock	*Overall stock statistics*
Ecosystem Extent	Kelp Canopy Cover (in-situ)
	Total Kelp Forest Area (Satellite)
Stock of Natural Aquatic Resources	Fish stocks
(Vertebrates)	–
Stock of Natural Aquatic Resources	Urchin abundance
(Invertebrates)	Abalone abundance
	Lobster abundance
Stock of Cultivated Aquatic Resources	Gross Piscivorous Fish Grown
(Vertebrates)	Gross Planktivorous Fish Grown
Stock of Cultivated Aquatic Resources	Gross Shellfish grown
(Invertebrates)	Gross Macroalgae Available for Harvested
Stock of Abiotic Resources	Alginate Available for Extraction
Ocean Services (Flows to the Economy)	
Regulating	*Conditions affecting flow of service*

Greenhouse Gas Sequestration	Light Availability
	Kelp Biomass
	Kelp Canopy Cover
Coastal Protection	Coastal geomorphology
	Kelp Canopy Density
	Wave fetch
	Abundance of Urchins (and removed)
	Storm Frequency
Erosion Control	Localized Hydrodynamics
	Distance to Metropolitan Area
	Kelp Canopy Cover
Water Purification	Kelp/Macroalgae Abundance
	Light Availability
Nutrient Cycling	Kelp Growth Rate
	Standing Stock of Carbon
	Light availability
Waste Remediation	Ratio of Turf:Macroalgae
	Kelp Canopy Cover
Pollutant Remediation	Fertilizer Concentrations
	Fish Farm Runoff

Provisioning	Conditions affecting flow of service/economic values
Maintenance of Fisheries	Fish Catch and Value
	Catch Per Unit Effort
	Kelp Cover
Cultivated Resources Extracted	Value of Cultivated Vertebrates
	Value of Cultivated Macroalgae
Raw Materials Extracted	Alginate Extracted
Cultural	Service levels and values
Tourism/Recreation	Kelp Persistence
	Scuba Diving Frequency
	Spatial coverage of Marine Protected Area
	Recreational Fisheries
Education/Research	Net Expense on Research
	Net Expense on Education
Religious/Spiritual/Indigenous	Cultural Heritage Area
Ocean Governance	*Activities, status, expenditures and value statistics*
Regulation	License Fees/Taxes
	Taxes on Cultivated Resources
	Taxes on Natural Resources
Enforcement	Permit Income

	Penalties/Fines
Restoration/Conservation	Transplant costs
	Invasive Species Abundance
	Fish Biomass
	Number/Size of Marine Protected Areas
Mitigation	Area/Abundance of Urchins Removed
	Area Restored with Kelp
Gross value added by sector	Gross value added of all Ocean Services by sector
Expenditure	Expenditures on environmental protection and maintenance

Table 45. Seagrass ecosystem core statistics

Ecosystem Type: Seagrasses	
Category	**Statistic**
Ocean Assets	
Condition	*Overall condition measures*
Biodiversity	Seagrass cover (Satellite imaging)
	Seagrass diversity/abundance (benthic surveys)
	Megafauna Abundance Counts (ex: Dugongs)
Ecosystem Fitness	Vegetation Type (Species Diversity)
	Seagrass Density (per m^2)

	Sedimentation Rate
Biogeochemical Cycling	Sediment Redox Potential (mV)
	Dissolved Organic Carbon Release Rate
	Inundation Depth
	C:N Sediment ratios
	Production: Respiration Ratio (per m^2)
Physiochemical Quality	Water Temperature
	Light Availability
	Salinity
Greenhouse Gas Retention	Nitrification Rate
	Carbon Dioxide Flux
	Total Water Storage (per m^2)
	Total Organic Carbon (per m^2)
Stock	*Overall stock statistics*
Ecosystem Extent	Seagrass/Vegetation Cover (satellite)
	Total Area of Saline High Tide Extent (satellite)
Stock of Natural Aquatic Resources	Artisanal Fishery Catch
(Vertebrates)	Commercial Fishery Catch
	Recreational Fish Catch
Stock of Natural Aquatic Resources	Gross Shellfish Harvested

(Invertebrates)	Gross Shrimp Harvested
	Gross Seagrass Harvested
Stock of Cultivated Aquatic Resources	Gross Planktivorous Fish Grown
(Vertebrates)	
Stock of Cultivated Aquatic Resources	Gross Shellfish Grown
(Invertebrates)	Gross Shrimp Grown
Stock of Abiotic Resources	Agricultural Services
Ocean Services (Flows to the Economy)	
Regulating	*Conditions affecting flow of service*
Greenhouse Gas Sequestration	Coastal geomorphology
	Sediment deposition rate
	Vegetation Cover
	Seagrass Blade Length
Coastal Protection	Sedimentation Rate
	Tidal Range
	Water Table Height
	Rooted Plant Cover
	Storm Frequency
Erosion Control	Fluvial sediment deposition
	Sea level rise

	Growth Form: Submerged
Water Purification	Aquatic Plant Leaf Size
	Sediment/Nutrient Load
	Root Type
Nutrient Cycling	Nitrification Rate
	Biological Oxygen Demand
	Sulphate Reduction Rate
Waste Remediation	Sediment Organic Carbon Content
	Sediment Organic Nitrogen Content
	Fish/Shrimp Farm Wastewater Discharge Rate
Pollutant Remediation	Terrestrial Runoff Rate
	Fertilizer Concentrations
Provisioning	*Conditions affecting flow of service/economic value*
Maintenance of Fisheries	Prey Fish Abundance
	Hydrodynamic Conditions
	Primary Productivity Rate (Chl a)
	Vegetation Cover
Cultivated Resources Extracted	Value of Cultivated Vertebrates
	Value of Cultivated Invertebrates, Algae, Plants
Raw Materials Extracted	Agricultural Products

Cultural	*Service levels and values*
Tourism/Recreation	Prey Fish Abundance
	Hydrodynamic Conditions
	Primary Productivity Rate (Chl a)
	Vegetation Cover
	Value of Cultivated Vertebrates
Education/Research	Value of Cultivated Invertebrates, Algae, Plants
	Agricultural Products
	Prey Fish Abundance
Religious/Spiritual/Indigenous	
Ocean Governance	*Activities, status, expenditures and value statistics*
Regulation	License Fees/Taxes
	Taxes on Cultivated Resources
	Taxes on Natural Resources
Enforcement	Permit Income
	Penalties/Fines
Restoration/Conservation	Area Conserved (no take)
	Area Conserved (recreational take only)
	Biomass Restocked (vertebrates)
	Biomass Restocked (invertebrates)

Mitigation	Length of Engineered Coastal Barriers
	Area Geoengineered
Gross value added by sector	Gross value added of all Ocean Services by sector
Expenditure	Expenditures on environmental protection and maintenance

Table 46. Salt Marsh and Estuary ecosystem core statistics

Ecosystem Type: Salt Marshes and Estuaries	
Category	**Statistic**
Ocean Assets	
Condition	*Overall condition measures*
Biodiversity	Seagrass/Vegetation Cover
	Prey Fish Abundance
	Healthy Predator Populations
Ecosystem Fitness	Vegetation Type
	Seagrass Abundance/Cover
	Plant Height
Biogeochemical Cycling	Sediment Redox Potential
	Hypersalinity
	Inundation Depth
	C:N Sediment ratios
	Submerged Plant Growth Form

Physiochemical Quality	Water Temperature
	Light Availability
	Salinity
Greenhouse Gas Retention	Nitrification Rate
	Carbon Dioxide Flux
	Total Water Storage
	Total Organic Carbon
Stock	*Overall stock statistics*
Ecosystem Extent	Seagrass/Vegetation Cover
	Total Area of Saline High Tide Extent (satellite)
Stock of Natural Aquatic Resources	Stock Available for Artisinal Fishery
(Vertebrates)	Stock of Commercial Fish
	Stock of Recreational Fish
Stock of Natural Aquatic Resources	Stock of Shellfish Available for Harvest
(Invertebrates)	Stock of Shrimp Available for Harvest
	Stock of Crab Available for Harvest
Stock of Cultivated Aquatic Resources	Gross Planktivorous Fish Grown
(Vertebrates)	
Stock of Cultivated Aquatic Resources	Gross Shellfish Grown
(Invertebrates)	

Stock of Abiotic Resources	Minerals/Fertilizers Available for Extraction
Ocean Services (Flows to the Economy)	
Regulating	*Conditions affecting flow of service*
Greenhouse Gas Sequestration	Coastal geomorphology
	Sediment deposition rate
	Vegetation Cover
	Aquatic Plant Leaf Size
Coastal Protection	Coastal geomorphology
	Tidal Range
	Water Table Height
	Rooted Plant Cover
	Storm Frequency
Erosion Control	Fluvial sediment deposition
	Sea level rise
	Growth Form: Submerged
Water Purification	Aquatic Plant Leaf Size
	Sediment/Nutrient Load
	Root Type
Nutrient Cycling	Nitrification Rate
	Biological Oxygen Demand

	Sulfate Reduction Rate
Waste Remediation	Sediment Organic Carbon Content
	Sediment Organic Nitrogen Content
	Terrestrial Runoff Rate
Pollutant Remediation	Fertilizer Concentrations
	Sewage Waste Concentrations
Provisioning	*Conditions affecting flow of service/economic value*
Maintenance of Fisheries	Prey Fish Abundance
	Hydrodynamic Conditions
	Primary Productivity Rate (Chl a)
	Vegetation Cover
Cultivated Resources Extracted	Value of Cultivated Vertebrates
	Value of Cultivated Invertebrates
Raw Materials Extracted	Agricultural Products Extracted
Cultural	*Service levels and values*
Tourism/Recreation	Accessible Area for Recreation
	Water Quality
	Marine Mammal Tourism
	Abundance of Visually attractive flora
	Recreation Generated Income

Education/Research	Net Expense on Research
	Net Expense on Education
	Habitat quality and area
Religious/Spiritual/Indigenous	Cultural Heritage Area
Ocean Governance	*Activities, status, expenditures and value statistics*
Regulation	License Fees/Taxes
	Taxes on Cultivated Resources
	Taxes on Natural Resources
Enforcement	Permit Income
	Penalties/Fines
Restoration/Conservation	Area Conserved (no take)
	Area Conserved (recreational take only)
	Biomass Restocked (vertebrates)
	Biomass Restocked (invertebrates)
Mitigation	Length of Engineered Coastal Barriers
	Area Geoengineered
Gross value added by sector	Gross value added of all Ocean Services by sector
Expenditure	Expenditures on environmental protection and maintenance

Table 47. Sediment ecosystem core statistics

Ecosystem Type: Sediment	
Category	**Statistic**
Ocean Assets	
Condition	*Overall condition statistics*
Biodiversity	Benthic Microbial Community
	Fish Diversity
	Infaunal Invertebrate Diversity
Ecosystem Fitness	Production: Respiration Ratio
	Sulfate Reduction Rate
	Sediment Oxygen Profile
	Nitrification Rate
Biogeochemical Cycling	Nitrate Concentration
	Sulfate Concentration
	Sediment Redox Potential
	Particulate/Dissolved Organic C:N
	Dissolved Oxygen
	pH (total scale)
Physiochemical Quality	Water Temperature
	Salinity
	Mean Sea Level

Greenhouse Gas Retention	Benthic Production:Respiration Ratio
	Sediment Permeability
	Light Availability/Turbidity
	Average Sea State
Stock	*Overall stock statistics*
Ecosystem Extent	Total Area of Soft Bottom/Sediment (Satellite)
Stock of Natural Aquatic Resources	Gross benthal fish stock
(Vertebrates)	Gross infaunal fish stock
Stock of Natural Aquatic Resources	Gross Sea Cucumber Stock
(Invertebrates)	Gross Shellfish Stock
Stock of Cultivated Aquatic Resources	Gross Piscivorous Fish Grown
(Vertebrates)	Gross Planktivorous Fish Grown
Stock of Cultivated Aquatic Resources	Gross Shellfish grown
(Invertebrates)	
Stock of Abiotic Resources	Sand Available for Harvest
Ocean Services (Flows to the Economy)	
Regulating	*Conditions affecting flow of service*
Greenhouse Gas Sequestration	Coastal geomorphology
	Sediment deposition rate
	Sediment Permeability

	Light availability
Coastal Protection	Coastal geomorphology
	Tidal Range
	Water Table Height
	Storm Frequency
Erosion Control	Fluvial sediment deposition
	Sea level rise
	Area of physical structure
Water Purification	Microphytobenthic composition
Nutrient Cycling	Nitrification Rate
	Biological Oxygen Demand
	Sulfate Reduction Rate
Waste Remediation	Sediment Organic Carbon Content
	Sediment Organic Nitrogen Content
	Plastic Pollutant Load
	Terrestrial Runoff Rate
Pollutant Remediation	Fertilizer Concentrations
	PCB Concentrations
	Trace Metal Concentrations
Provisioning	Condition affecting flows of service/economic values

Maintenance of Fisheries	Catch Rate and value
	Catch Per Unit Effort
Cultivated Resources Extracted	Value of Cultivated Vertebrates
	Value of Cultivated Invertebrates
Raw Materials Extracted	Quantity and Value of Sand Extracted
Cultural	Service level and values
Tourism/Recreation	Accessible Area for Recreation
	Water Quality
	Tourism Generated Income
	Recreation Generated Income
Education/Research	Net Expense on Research
	Net Expense on Education
	Habitat quality and area
Religious/Spiritual/Indigenous	Cultural Heritage Area
Ocean Governance	*Activities, status, expenditures and value statistics*
Regulation	License Fees/Taxes
	Taxes on Cultivated Resources
	Taxes on Natural Resources
Enforcement	Permit Income
	Penalties/Fines

Restoration/Conservation	Area Conserved (no take)
	Area Conserved (recreational take only)
	Biomass Restocked (vertebrates)
	Biomass Restocked (invertebrates)
Mitigation	Length of Engineered Coastal Barriers
	Area Geoengineered
Gross value added by sector	Gross value added of all Ocean Services by sector
Expenditure	Expenditures on environmental protection and maintenance

Table 48. Open Ocean ecosystem core statistics

Ecosystem Type: Open Ocean	
Category	**Statistic**
Ocean Assets	
Condition	*Overall condition statistics*
Biodiversity	Megafauna Abundance/Diversity
	Fish Diversity
	Plankton abundance
Ecosystem Fitness	Chlorophyll a concentration
	Biological Pump Rate
	Turbidity/Light availability

Biogeochemical Cycling	Thermocline
	Pycnocline
	Vertical Profile: Oxygen
	Vertical Profile: Nitrate
	Vertical Profile: pH
	Vertical Profile: DIC
Physiochemical Quality	Sea Surface Temperature
	Sea Surface Salinity
	Mean Sea Level
Greenhouse Gas Retention	Plankton Abundance
	Chlorophyll a Concentration
	Dissolved Inorganic Carbon Profile
	Average Sea State
Stock	*Overall stock statistics*
Ecosystem Extent	Total area defined as open ocean (satellite)
Stock of Natural Aquatic Resources	Gross pelagic fish catch
(Vertebrates)	Gross piscivorous fish catch
Stock of Natural Aquatic Resources	Gross shrimp catch
(Invertebrates)	Gross squid catch
Stock of Cultivated Aquatic Resources	Gross Pelagic Fish Grown

(Vertebrates)	
Stock of Cultivated Aquatic Resources	Gross Shellfish Grown
(Invertebrates)	Gross Shrimp Grown
Stock of Abiotic Resources	Oil/Petroleum Harvested
	Energy Generated
Ocean Services (Flows to the Economy)	
Regulating	*Conditions affecting flow of services*
Greenhouse Gas Sequestration	Average Sea State
	Chlorophyll a (Satellite)
	SST (Satellite)
Coastal Protection	Mean Sea Level
	Hydrodynamic Barrier Area
Erosion Control	Water Column Sedimentation Rates
Water Purification	Plankton Abundance
	Chlorophyll a Concentration
Nutrient Cycling	Biological Pump Rate
	Chlorophyll a Concentration (satellite)
	Dissolved Inorganic Carbon Profile
Waste Remediation	Water Column PON
	Water Column POC

	Plastic Pollutant Load
	Terrestrial Runoff Rate
Pollutant Remediation	Fertilizer Concentrations
	Microplastic Concentrations
	Large Plastic Concentrations
Provisioning	*Conditions affecting flow of services/economic values*
Maintenance of Fisheries	Fish Catch and Value
	Catch Per Unit Effort
Cultivated Resources Extracted	Value of Cultivated Vertebrates
	Value of Cultivated Invertebrates
Raw Materials Extracted	Energy Generated
	Oil/Petroleum Extracted
Cultural	*Service levels and values*
Tourism/Recreation	Accessible Area for Recreation
	Water Quality
	Tourism Generated Income
	Recreation Generated Income
Education/Research	Net Expense on Research
	Net Expense on Education
Religious/Spiritual/Indigenous	Cultural Heritage Area

Ocean Governance	*Activities, status, expenditures and value statistics*
Regulation	License Fees/Taxes
	Taxes on Cultivated Resources
	Taxes on Natural Resources
Enforcement	Permit Income
	Penalties/Fines
Restoration/Conservation	Area Conserved (no take)
	Area Conserved (recreational take only)
	Biomass Restocked (vertebrates)
	Biomass Restocked (invertebrates)
Mitigation	Length of Engineered Coastal Barriers
	Area of Hydrodynamic Barriers
Gross value added by sector	Gross value added of all Ocean Services by sector

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7. Glossary

Aquatic resources comprise fish, crustaceans, molluscs, shellfish, aquatic mammals and other aquatic organisms (including microorganisms) that are considered to live within the boundaries of the exclusive economic zone (EEZ) of a country throughout their life cycles, including both coastal and inland fisheries. Migrating and straddling fish stocks are considered to belong to a given country during the period when those stocks inhabit its EEZ. (SEEA Central Framework 5.393, 5.398)

Biological resources include timber and aquatic resources and a range of other animal and plant resources (such as livestock, orchards, crops, and wild animals), fungi and bacteria. (SEEA Central Framework 5.24) (See also Cultivated biological resources, Natural biological resources, Other biological resources.)

BSU – The Basic Spatial Unit is the minimal spatial measurement unit used for ecosystem accounting. It generally corresponds to the pixel size of the satellite images (e.g., 30m by 30m) used to establish land cover. However, countries have also applied BSUs of irregular shape, such as cadastral (land registry) areas.

CICES - The Common International Classification of Ecosystem Services, in its current version (V5.1), lists 67 biotic (more directly linked to ecosystem processes) and 31 abiotic services (less directly linked to ecosystem processes) services. The CICES was originally developed from the work on environmental accounting undertaken by the European Environmental Agency (EEA). Although not an international standard, it is widely used for ecosystem accounting, especially in Europe.

CMECS - Coastal and Marine Ecological Classification Standard was developed by NOAA as a comprehensive and systematic classification of coastal and marine ecosystems. The main components are the water column (structure and characteristics of the water column), geoform (geomorphic structural character of the coast or sea floor), substrate (Character and composition of surface and near-surface substrates) and biotic (assemblages of benthic or suspended/floating biota). See https://iocm.noaa.gov/cmecs/ .

Cultivated biological resources cover animal resources yielding repeat products and tree, crop and plant resources yielding repeat products whose natural growth and regeneration are under the direct control, responsibility and management of an institutional unit. (SEEA Central Framework 5.24)

Degradation considers changes in the capacity of environmental assets to deliver a broad range of ecosystem services and the extent to which this capacity may be reduced through the action of economic units, including households. (SEEA Central Framework 5.90)

Depletion, in physical terms, is the decrease in the quantity of the stock of a natural resource over an accounting period that is due to the extraction of the natural resource by economic units occurring at a level greater than that of regeneration. (SEEA Central Framework 5.76)

EEZ - Exclusive economic zone of a country: the area extending up to 200 nautical miles from a country's normal baselines as defined in the United Nations Convention on the Law of the Sea of 10 December 1982. (SEEA Central Framework 5.248 and related footnote)

Household: a group of persons who share the same living accommodation, who pool some, or all, of their income and wealth and who consume certain types of goods and services collectively, mainly housing and food. (SEEA Central Framework 2.111)

Institutional unit: an economic entity that is capable, in its own right, of owning assets, incurring liabilities and engaging in economic activities and in transactions with other entities. (SEEA Central Framework 2.110)

LME - Large Marine Ecosystems characterize distinct bathymetry, hydrography, productivity and food webs of coastal ecosystems at a large scale (DOALOS, 2016). The LMEs is an ecologically-based definition, particularly suitable for addressing management issues, notably those pertaining to fisheries on continental shelves, and coastal area management.

MEOW Marine Ecosystems of the World is a biogeographic classification of the world's coasts and shelves. As a nested system of 12 realms, 62 provinces, and 232 ecoregions, MEOW provides a basis for planning units for coastal and shelf areas. MEOW suggested that the most appropriate outer boundary for coastal and shelf realms, provinces, and ecoregions is the 200-meter isobath.

MSDI - Marine Spatial Data Infrastructure Is a framework for storing, sharing and using spatial information about the ocean. The framework consists of 1) people (e.g., public/private providers and users), 2) data, 3) standards (e.g., resolution, projection, metadata, data quality assessment), 4) policy (e.g., data sharing/privacy policy, coordination structure), and 5) the access network. Spatial Data Infrastructure frameworks traditionally focus on land administration and management and are already integrated with land accounts in many countries. May also be referred to as “marine cadastres” or “marine GIS”.

Natural biological resources consist of animals, birds, fish and plants that yield both once-only and repeat products for which natural growth and/or regeneration is not under the direct control, responsibility and management of economic units. (SEEA Central Framework 5.24)

NSDI - National Spatial Data Infrastructure is a framework for storing, sharing and using spatial information. Many countries have initiated OneMap programs to integrate official maps from different government sectors (e.g., environment, forestry, agriculture, land administration…). As with MSDI, the best practice is to ensure that the providers and users, the data itself, the standards that are applied, the applications of the data and the means of access are considered in the design.

Ocean services are biotic and abiotic contributions of the ocean to the economy and other human activities. Biotic services are synonymous with what are generally considered to be “ecosystem services”, that is the components of nature enjoyed, consumed or used to yield human well-being”. Abiotic services are generally thought of as the non-living commodities, such as minerals and seawater, but could also include abiotic energy sources (wind, tidal, etc.), results of physical processes (such as upwelling to recycle nutrients), results of chemical processes (e.g., buffering ocean acidification).

Other biological resources comprise all biological resources, both cultivated and natural, other than timber resources and aquatic resources. (SEEA Central Framework 5.460, 5.461)

PSUT - Physical Supply and Use Tables are applied in the SEEA to trace the flow of physical units of natural inputs from the environment to the economy, within the economy and the returns of associated residuals back to the environment. PSUTs are described for materials (generally all materials such as biomass, fossil fuels, minerals, non-metallic minerals). water and energy. PSUTs may be compiled for specific materials, such as timber or fish. PSUTs are also described for residuals, such as air emissions, water emissions and solid waste. In the case of residuals, the “supply” (generation) comes from the consumption of materials and energy.

Rent is the income receivable by the owner of natural resources or land (the lessor or landlord) for putting the natural resource or land at the disposal of another institutional unit (a lessee or tenant) for use of the natural resource or land in production. (SEEA Central Framework 4.161)

Residuals are flows of solid, liquid and gaseous materials, and energy, that are discarded, discharged or emitted by establishments and households through processes of production, consumption or accumulation. (SEEA Central Framework 2.92, 3.73)

Seamounts are underwater mountains rising from the ocean seafloor, but not reaching the water’s surface.

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