Global Manual on Ocean Statistics for Measuring SDG 14.1.1, 14.2.1 and 14.5.1

UN environment

14 LIFE BELOW WATER

Executive summary

Importance and challenge of monitoring the ocean

The ocean provides essential ecosystem services for human populations, from global climate regulation to local livelihoods and nutrition. Monitoring is key to understanding the ocean: How is the state of the ocean changing? Who is benefiting from the change and who is losing out? What is causing the changes? How well are our efforts to address the changes working?

The ocean covers 70 percent of the surface of the Earth. Yet, compared to terrestrial systems, marine ecosystems and biodiversity are still poorly understood. The main reason for our limited understanding of the ocean is that most marine ecosystems are remote, vast in size and difficult to access, making marine research expensive and logistically challenging. Gathering data on marine biodiversity and ecosystem conditions requires advanced technologies and equipment, such as oceanographic research vessels, submersibles, remotely operated vehicles, specially designed sensors and remote sensing facilities. Moreover, the dynamic and connected nature of the marine environment present additional challenges: monitoring methodologies that work well in one location may not be suitable or relevant in another.

When monitoring the ocean, it is important to consider the high degree of connectivity that exists within the marine environment, but also between marine and terrestrial systems. Most of the changes in marine ecosystems are caused by activities on land. For example, nutrient run-off from agriculture is a main cause of eutrophication of coastal waters, and mismanaged plastic waste from coastal communities often ends up in the ocean. About 40 percent of the Earth's population lives on the coast, and approaches like Integrated Coastal Zone Management (ICZM) have recognised the need for integrated marine and terrestrial management of these coastal zones. In this context, it is important to note that the agreed SDG 14 Indicators (and proposed indicators) relate to measuring the state and quality of the impacted ecosystems, rather than measuring the drivers and pressures underlying these. Hence, their purpose is to assess the success of measures put in place to prevent marine issues such as marine litter or eutrophication. Althgouth this manual focuses on measuring the marine environment, it is important to use this information in conjunction with other information related to the terrestrial environment, freshwater, climate and the socio-economic situation

SDG 14 'Life below water' and country-level perspectives

Sustainable Development Goal SDG 14 *'Life below water'* sets the aim to *conserve and sustainably use the oceans, seas and marine resources for sustainable development*. UN Environment is the custodian agency for the following indicators related to SDG 14:

14.1.1a Index of Coastal Eutrophication

14.1.1b Plastic debris density

14.2.1 Number of countries using ecosystem-based approaches to manage marine areas

14.5.1 Coverage of protected areas in relation to marine areas

The purpose of the *Global Manual on Ocean Statistics* is to support countries in their efforts to track progress against the delivery of SDG 14, by providing a step-by-step guide to implementing the three indicators (14.1.1.a, 14.1.1.b and 14.2.1) under UN Environment custodianship (see Table 2 for indicators and related SDG 14 Targets). This document provides a step-by-step structure of the indicator methodologies, which was thought to promote coherent approaches across and within countries.

Table 1: Sustainable Development Goal (SDG) 14 Targets for which UN Environment is the custodian agency of the indicators. See Table 1 for tier classification. SDG Target 14.1 is analogous to Aichi Target 8[1] of the UN Strategic Plan for Biodiversity 2010-2020, for which global indicators are not yet available. SDG Target 14.5 is analogous to Aichi Target 11[2].

Target number	Target name	Indicator number	Indicator name	Custodian agency (and others involved)	Tier class.
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	14.1.1a	Index of Coastal Eutrophication (ICEP)	UN Environment (IOC-UNESCO, FAO)	3
		14.1.1b	Plastic debris density	UN Environment (IOC-UNESCO, FAO)	3
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	Number of countries using ecosystem-based approaches to manage marine areas	UN Environment (IOC-UNESCO, FAO)	3
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	UN Environment (UNEP-WCMC)	1

For SDG Indicator 14.5.1, an internationally established methodology already exists and thus it is not extensively covered in this manual. Instead, the *Global Manual* points towards the existing methodology for SDG Indicator 14.5.1 which is based on the World Database on Protected Areas (WDPA).The coverage of protected areas in relation to marine areas is calculated using the WDPA, based on national data which countries either submit into the WDPA, or approve.

The *Global Manual* provides step-by-step methodologies for implementing the indicators for SDG Indicators 14.1.1a, 14.1.1b and 14.2.1. The methodologies are designed to be globally applicable approaches that provide the minimum data required to implement the SDG indicators at country-level. This is particularly relevant to countries with limited resources and technical capacities, notably countries with relatively large marine national waters such as “island nations”.

[1] Aichi Target 8: *By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity*. For more information about the target: https://www.cbd.int/aichi-targets/target/8

[2] Aichi Target 11: *By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes*. For more information about the target: https://www.cbd.int/aichi-targets/target/11

Contents

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Core drafting team

The Manual was drafted by a core team of lead authors consisting of Jillian Campbell (UNEP), Laura Friedrich (UNEP-WCMC) and Sarah Ivory (UNEP-WCMC).

Contributors and overall coordination

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List of acronyms

Acronym	English name
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AZE	Alliance for Zero Extinction
BOD	Biological oxygen demand
CAFF	Conservation of Arctic Flora and Fauna
CBD	Convention on Biological Diversity
CCAMLR	Convention for the Conservation of Antarctic Marine Living Resources
CEOS	Committee on Earth Observation Satellites
CMEMS	Copernicus Marine Environment Monitoring Service
COD	Chemical oxygen demand
CPPS	Commission for the South Pacific
CSO	Civil Society Organisation
CZCS	Coastal Zone Color Scanner
DIN	Dissolved inorganic nitrogen
DIP	Dissolved inorganic phosphorus
EBSA	Ecologically or Biologically Significant marine Areas
ESA	European Space Agency
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FAO	Food and Agriculture Organization (of the United Nations)
GCOM-C	Global Changing Observation Mission
GEF-TWAP	Global Environment Facility Transboundary Waters Assessment Programme
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GIS	Geographic information system
HELCOM	Baltic Marine Environment Protection Commission – Helsinki Commission
IAEG-SDGs	Inter-agency and Expert Group on SDG Indicators
IBA	Important Bird and Biodiversity Area
IBTS	International Bottom Trawl Surveys
ICC	International Coastal Clean-up
ICEP	Index of Coastal Eutrophication
ICZM	Integrated Coastal Zone Management
INVEMAR	Colombian Marine and Coastal Research Institute
IOC-UNESCO	Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization
IUCN	International Union for Conservation of Nature
JAMP	Joint Assessment and Monitoring Programme
JAXA	Japan Aerospace Exploration Agency
JRC	Joint Research Council (of the European Commission)
KBA	Key Biodiversity Area
MAB	Man and Biosphere Reserves (UNESCO)
LME	Large Marine Ecosystem
MDG	Millenium Development Goal
MERIS	Medium Resolution Imaging Spectrometer
MODIS	Moderate Resolution Imaging Spectroradiometer
MPA	Marine Protected Area

MSFD	Marine Strategy Framework Directive
MSP	Marine (or Maritime) Spatial Planning
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NOWPAP	Northwest Pacific Action Plan
OSPAR	Oslo Paris Convention for the Protection of the Marine Environment of the North-East Atlantic
OLCI	Ocean and Land Colour Instrument
OLI	Operational Land Imager
PDF	Portable Document Format
PERSGA	Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden
PNN	National Natural Parks (Colombia)
PSSA	Particularly Sensitive Sea Area
ROMPE	Regional organization for the Protection of the Marine Environment
RUNAP	Colombian National Register of Protected Areas (in Spanish: Registro Único de Áreas Protegidas)
SeaWiFS	Sea-Viewing Wide Field-of-View Sensor
SDG	Sustainable Development Goals
SPREP	Secretariat of the Pacific Regional Environment Programme
STEP	Science Toolbox Exploitation Platform
TOC	Total organic carbon
TRIS	Thermal Infrared Sensor
UAC	Coastal and Oceanic Environmental Unit (in Spanish: Unidad Ambiental Costera)
UN	United Nations
UNEP	UN Environment
UNEP-MAP	UN Environment Mediterranean Action Plan (also Barcelona Convention)
UNEP-WCMC	UN Environment World Conservation Monitoring Centre
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNSD	United Nations Statistics Division
VIIRS	Visible Infrared Imaging Radiometer Suite
VME	Vulnerable Marine Ecosystem
WDPA	World Database on Protected Areas
WFD	Water Framework Directive
WHS	World Heritage Site

List of Regional Seas Programmes

Antarctic Sea	Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Antarctic Treaty
Arctic Sea	Arctic Council, Ottawa Declaration
Baltic Sea	Helsinki Commission (HELCOM), Helsinki Convention
Black Sea	Black Sea Commission, Bucharest Convention
Caspian Sea	Caspian Environment Programme, Tehran Convention
East Asian Seas	East Asian Seas Action Plan
Mediterranean Sea	UN Environment Mediterranean Action Plan (UNEP-MAP), Barcelona Convention
Northeast Atlantic	Oslo-Paris Convention (OSPAR) for the Protection of the Marine Environment of the North-East Atlantic
Northeast Pacific	Antigua Convention
Northwest Pacific	Northwest Pacific Action Plan (NOWPAP)
Pacific	Pacific Regional Environment Programme, Secretariat of the Pacific Regional Environment Programme (SPREP), Noumea Convention
Red Sea and Gulf of Aden	Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA), Jeddah Convention
ROMPE Sea Area*	Regional organization for the Protection of the Marine Environment (ROMPE), Kuwait Convention **(the ROMPE Sea Area refers to the marine and coastal areas of Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates)*
Sargasso Sea	Hamilton Declaration
South Asian Seas	South Asia Cooperative Environment Programme, South Asian Seas Action Plan
Southeast Pacific	Permanent Commission for the South Pacific (CPPS), Lima Convention
West and Central Africa	Abidjan Convention
Western Indian Ocean	Nairobi Convention
Wider Caribbean	Caribbean Environment Programme, Cartagena Convention

Part 1: Context of the *Global Manual*

Sustainable Development Goals and indicators

At the United Nations (UN) General Assembly in September 2015, Heads of States and Governments agreed on 17 Sustainable Development Goals (SDGs) as framework for the 2030 Agenda for Sustainable Development. The SDGs integrate the three dimensions of sustainable development (biosphere, society and economy, as illustrated in Figure 1) and aim to foster action for people, planet, prosperity, peace and partnership. For each high level goal, a number of specific targets have been agreed by the countries. (Further details on the individual SDGs and targets can be found at https://sustainabledevelopment.un.org/sdgs).

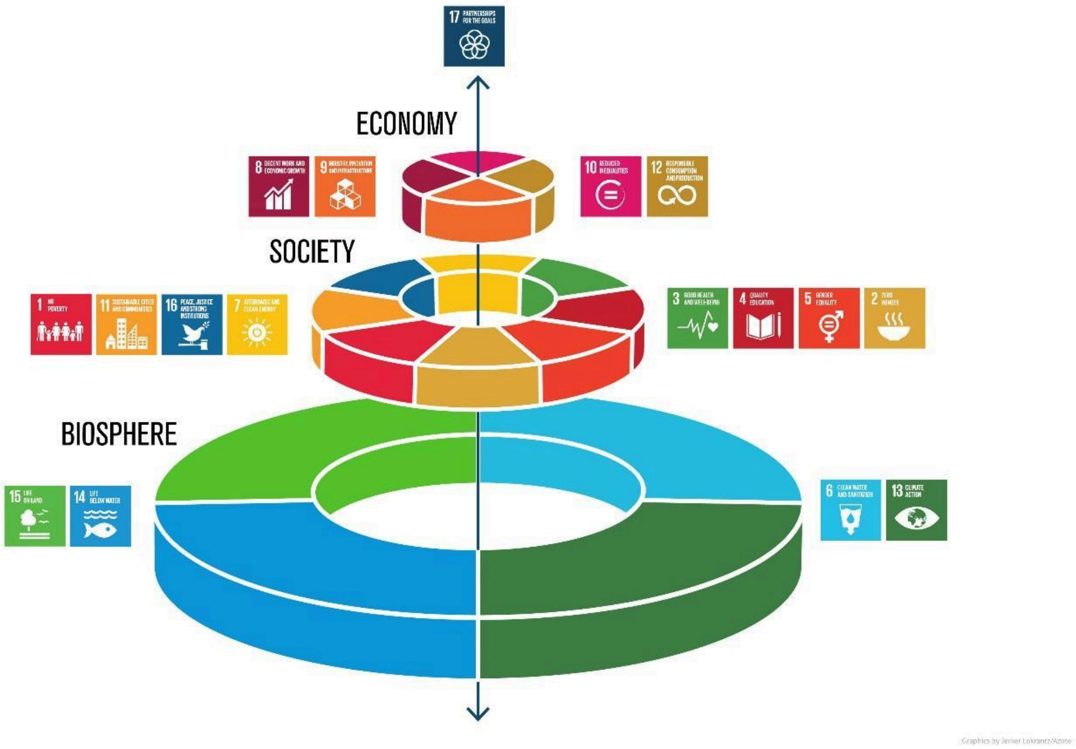

Figure 1: Illustration of the 17 Sustainable Development Goals across the three spheres of sustainable development: biosphere, society and economy. Credit: Azote Images for Stockholm Resilience Centre.

To keep track of progress against these global goals and associated targets, the Inter-agency 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 to their national capacities.

Data and information flows for reporting on SDG 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, as illustrated in Figure 2.

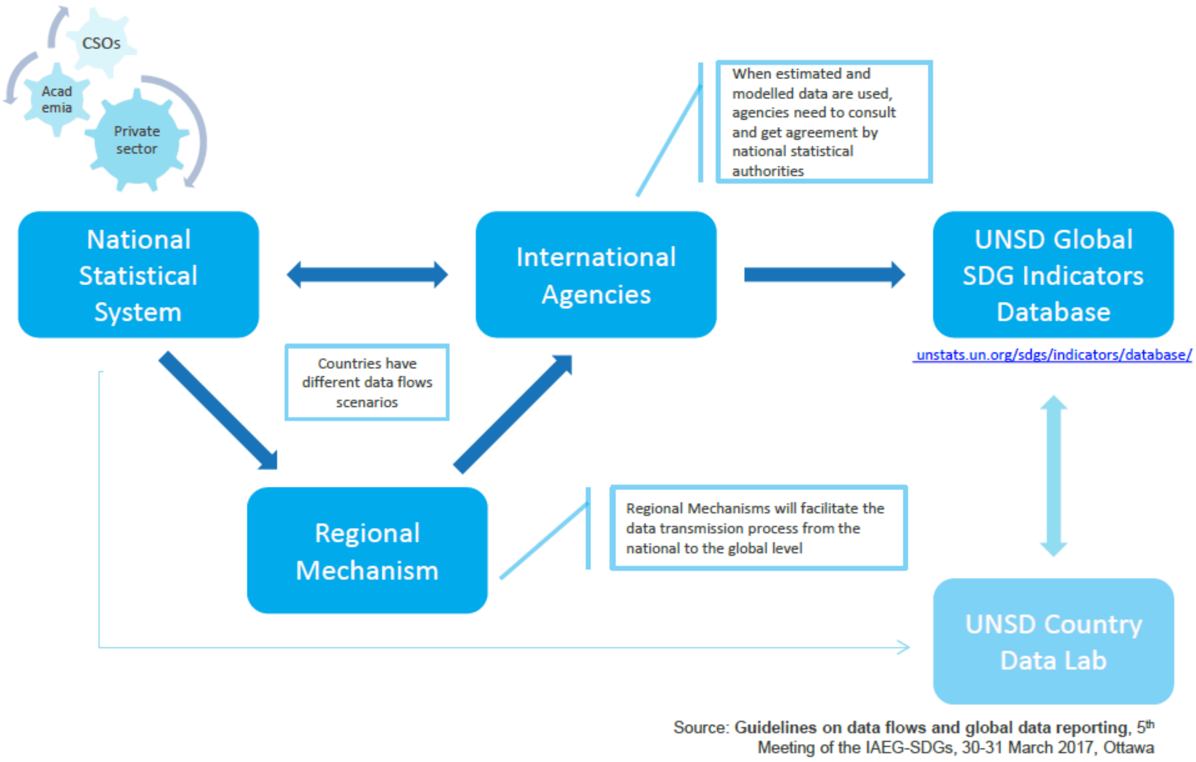

Figure 2: Anticipated Sustainable Development Goal data flow and reporting process. UNSD: UN Statistics Division; CSOs: Civil Society Organisations.

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[3]. 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 (www.unstats.un.org/sdgs/indicators/database), which is maintained by the UN Statistics Division (UNSD).

Each SDG indicator falls under the responsibility of a specific international agency which functions as custodian agency for the indicator. Custodian agencies are UN bodies and other international organisations, such as the UN Environment World Conservation Monitoring Centre (UNEP-WCMC),

[3] For information about the Regional Seas Programmes: http://web.unep.org/regionalseas/who-we-are/regional-seas-programmes

that are responsible for facilitating the data and information flow from the national to the global level. The custodian agencies also have the responsibility to standardise SDG indicator methodologies and to support countries in strengthening national statistical capacity and reporting mechanisms.

Complexities of ocean monitoring and marine indicators

Note that there is a layer of complexity added by a multitude of different jurisdictions, or lack thereof, in the ocean. Depending on the country, territorial waters can extend to 12 nautical miles and exclusive economic zones (national waters) can reach out to 200 nautical miles. However, over 60 percent of the ocean surface and nearly 95 percent of the volume lie in areas beyond national jurisdiction, also called the high seas, where responsibilities for monitoring and reporting are not always straightforward.

In the high seas, monitoring often relies on international scientific cooperation efforts, due to the vast areas involved and the cost of accessing remote marine environments, including the deep sea. One cost-effective method for accessing these areas, requiring low technological capacity, is through international remote sensing initiatives that use satellite telemetry to monitor large areas of the high seas over time. These remote sensing initiatives provide insight on physical, biological and biogeochemical ocean parameters. However, satellite sensors are less suitable for monitoring species and habitat biodiversity, or even pollutants such as marine plastics, for which *in situ* data collection is usually more appropriate. The issue here is that the cost of *in situ* monitoring and lack of national mandates in the high seas limit the options for such primary data collection..

About the *Global Manual*

The *Global Manual on Ocean Statistics* provides guidance for national governments and national institutions to support the country-level implementation of SDG Indicators 14.1.1a, 14.1.1b, 14.2.1 and 14.5.1 (full names in Table 2) in their national waters.

Note that there a a number of challenges and limitations facing monitoring in the high seas are particularly problematic for transboundary marine issues such as ocean acidification or marine plastics. For such issues, the monitoring of national waters, which is the primary focus of the SDG indicators, only shows part of the picture. This manual focuses on national monitoring, but there is a need for additional research and support to measure the areas beyond national jurisdiction for analytical use, including for analysis of the SDGs

Progressive monitoring approach

Agenda 2030 is a country-led and country-owned process. The *Global Manual* embraces this approach which places responsibility on countries to monitor and report data on all SDG indicators. The environmental dimension of the SDG indicators is relatively new compared to the Millenium Development Goals (MDGs) and nationally-derived environmental data has not often been captured before. With this in mind, the methodology proposed in this manual encourages the use of globally available environmental data to enhance country-derived data, filling data gaps and enabling countries to more rapidly make progress towards achieving SDG targets. For SDG 14.1.1, both coastal eutrophication and marine litter, a progressive monitoring approach is proposed which brings together globally modelled data and national data. This same approach has been adopted for other SDG indicator methodologies, such as Indicator 6.6.1 and 15.3.1.

This progressive monitoring approach means that countries can utilize both globally- and nationally-derived data to report on Indicator 14.1.1. Where countries have the data and capacity to do so, they should aim to report on all aspects of Indicator 14.1.1. While it is beneficial to capture data on all aspects of the Indicator, it is recognised that not all countries may have all required data available to achieve this. Therefore, the progressive monitoring approach presented here encourages different levels of ambition, depending on a country's capacity.

The progressive monitoring approach uses 3 Levels. Level 1 data utilizes data which is already globally available and for which UNEP will produce data products. This allows to establish a foundation which can be strengthened by countries as they develop capacity and ability to report on Level 2 data and Level 3 data. Level 2 data is recommended for national data collection in all countries. Level 3 data is a list of supplementary information which is suggested that countries consider monitoring, but this manual does not go into detail on the Level 3 indicators. All globally available data will be shared with national statistical offices and other relevant authorities for in-country validation. Since this global data is derived from global algorithms, some countries may choose to provide their own data derived from regionally tuned algorithms as part of the Level 2 data.

Definitions

Eutrophication – excess nutrient loading into coastal environments from anthropogenic sources, resulting in excessive growth of plants, algae and phytoplankton.

Coastal Zone – national Exclusive Economic Zone (EEZ) (200 nautical miles from the coast) as outlined by the United Nations Convention on the Law of the Sea.

Marine litter - any persistent, manufactured or processed solid material which is lost or discarded and ends up in the marine and coastal environment.

Part 2: Step-by-step guides to indicator implementation

Indicator 14.1.1a: Index of Coastal Eutrophication (including ICEP)

Target 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

Background

Coastal areas are areas of high productivity where inputs from land, sea, air and people converge. With over 40 percent of the human population residing in coastal areas, ecosystem degradation in these areas can have disproportionate effects on society (IGOS, 2006). One of the largest pressures on coastal environments is eutrophication, resulting primarily from land-based nutrient input from agricultural runoff and domestic wastewater discharge. Coastal eutrophication can lead to serious damage to marine ecosystems, vital sea habitats, and can cause the spread of harmful algal blooms.

Target 14.1 aims to reduce the impacts of pollution through prevention and reduction of marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution. Due to the significant amount of data and resources required to calculate nutrient loading, a progressive methodology is proposed which promotes country-derived data collection to be complimented by other globally available datasets such as publicly available satellite remote sensing products that can be used a proxy indicators for eutrophication. Note that it is important to consider the sources of nitrogen in developing nitrogen related interventions.

Proposed indicators for SDG reporting

SDG Indicator 14.1.1a aims to measure the contribution to coastal eutrophication from countries and the state of coastal eutrophication. Therefore, two levels of indicators are recommented with an optional third level for relevant countries:

Level 1: Proposed global indicators

Indicator for Coastal Eutrophication Potential (based on Nitrogen and Phospahte loadings)

Chlorophyll-a deviations (percentage of EEZ area with a devitation of more than 50%) per year

Level 2: Proposed national indicators

Chlorophyl-A concentration

National modelling of coastal eutrophication potential

In-situ concentration of nitrogen, phosphate and silica

Level 3: Supplementary indicator

Described in the below table for information. The in situ indicators proposed below match with the methods presented in SDG 6.3.2

Table 1: Monitoring parameters for eutrophication to track progress against SDG Indicator 14.1.1a.

Monitoring parameters	Level 1	Level 2	Level 3
Indicator for Coastal Eutrophication Potential (N and P loading)	X		

Chlorophyll-a deviations (remote sensing)	X		
Chlorophyll-a concentration (*remote sensing and in situ*)		X	
National modelling of indicator for Coastal Eutrophication Potential (ICEP)		X	
Total Nitrogen of DIN (dissolved inorganic nitrogen)		X	
Total Phosphorus or DIP (dissolved inorganic phosphorus)		X	
Total silica		X	
Dissolved oxygen			X
Biological/chemical oxygen demand (BOD/COD)			X
Total organic carbon (TOC)			X
Turbidity (remote sensing)			X
River parameters from SDG 6.3.2			X
Other water parameters (O_2 % saturation, Secchi depth, river discharge, salinity, temperature, pH, alkalinity, organic carbon, toxic metals, persistent organic pollutants)			X
Microalgal growth, harmful algal blooms, submerged aquatic vegetation coverage, biodiversity and hypoxia			X

These indicators are marked as levels 1, 2 or 3, level 1 being global data or globally modelled, level 2 including national monitoring and level 3 describing supplementary/recommended indicators.

Step-by-step guide to implementing the indicator

Level 1: Indicator for coastal eutrophication potential

The indicator for coastal eutrophication potential (ICEP), is based on loads and ratios of nitrogen, phosphorus and silica delivered by rivers to coastal waters. This indicator assumes that excess nitrogen or phosphorus relative to silica will result in increased growth of potentially harmful algae (ICEP>0). This indicator is based on loads and ratios of nitrogen, phosphorous and silica delivered by rivers to coastal waters (Garnier et al. 2010) which contribute to the ICEP. The basis for these loads is collected from land-based assessments of land use including fertilizer use, population density, socioeconomic factors and other contributors to nutrient pollution runoff. Given the land-based nature of the indicator, it provides a modelled number indicating the risk of coastal eutrophication at a specific river mouthn. The indicator can be further developed by incorporating in situ monitoring to evaluate the dispersion of concentrations of nitrogen, phosphorous and silica to ground-truth the index. The indicator assumes that excess concentrations of nitrogen or phosphorus relative to silica will result in increased growth of potentially harmful algae (ICEP>0). ICEP is expressed in kilograms of carbon (from algae biomass) per square kilometre of river basin area per day (kg C km^{-2} day^{-1}).

The ICEP model is calculated using one of two equations depending on whether nitrogen or phosphorus is limiting. The equations (Billen and Garnier 2007) are

*ICEP (N limiting) = [NFlx/(14*16)-SiFlx/(28*20)]*106*12*

*ICEP (P limiting) = [PFlx/31 – SiFlx/(28*20)]*106*12*

Where PFlx, NFlx and SiFlx are respectively the mean specific values of total nitrogen, total phosphorus and dissolved silica delivered at the mouth of the river basin, expressed in kg P km^{-2} day^{-1}, in kg N km^{-2} day^{-1} and in kg Si km^{-2} day^{-1}.

In order to populate the variables in the ICEP, the values of total nitrogen, total phosphorus and dissolved silica delivered at the mouth of the river basin must be modelled. There are various methods that have been employed to model these values. The modelling is based on globally available data and data collected directly from countries. To quantify nutrien texport by rivers, the information is needed for hydrology, socio-economic drivers, urbanization and nutrient managment. Hydrology can be derived from various global hydrological models. The socio-economic, urbanization and nutrient managment data are avaiable from different soruces (e.g., FAO national statistics, global models such as IMAGE, MAgPIE, Globiom model), but vary greatly in spetial and temporal level of detail (e.g., national versus 0.5 degre cell). Exampels of the required data to quantify nutrien texport by rivers is presented in Tabel 1.

Table 2: Examples of the data needed to quantify nutrient export by rivers that is used in ICEP estimates

Hydrology and retentions in rivers
○ Actual ("disturbed") basin discharge
○ Natural ("pristine") basin discharge
○ Fraction removed through consumptive water use
○ Basin-wide dam retention factor for DIN
○ Basin-wide dam retention factor for DIP
○ Basin-wide dam retention factor for TSS
Socio-economic data
○ Gross Domestic Product (GDP), at market exchange rate
○ Gross Domestic Product (GDP), at purchasing power parity
○ Population Density
○ Urban Population Density
○ Density of population connected to sewage system
○ Raw total elemental N &P emission to watershed from human waste (excrement)
○ Raw total phosphorus emission to watersheds from detergents (laundry + dishwasher)
○ Removal efficiencies of N and P during treatment
Land use data
○ Wetland
○ Agricultural land (e.g., cropland, legumes, pasture)
Nutrient managment data
○ Total fertilizer inputs to land
○ Animal manure inputs to land and to rivers

○	Atmospheric N depsotion on land
○	Biological N fixation by crops and natural vegetation

The Global NEWS model (originated in Mayorga *et al* 2010 and applied in Strokal *et al* 2016) is the most used global level analysis of basin level nutrient exports to river-mouths. This model uses river input data which takes into account fertilizer use, livestock data and other information mentioned in the above table and combines it with information on land cover and run-off modelling. It includes *point* and *diffuse* sources of nutrients in rivers, both of these are functions of the total dissolved nitrogen (TDN) and total dissolved phosphorus (TDP). For example variables for point sources of nutrients include direct discharges of animal manure to rivers and human sewage and variables for diffuse sources of nutrients include manure and synthetic fertilizers used in croplands, atmospheric N deposition, biological N fixation, leaching of organic matter, and P-weathering. The Global NEWS model measures the coastal eutrophication potential at the river mouth (i.e. the point when water flows into the ocean).

For SDG indicator 14.1.1a, further sub-basin level information is needed in order to nationalize the contribution of nutrients by countries to the ICEP. The MARINA (Strokal *et al* 2016) is a downscalled version of Global NEWS. MARINA calculates river export of nutrients at a sub-basin level (Global NEWS at a basin level). MARINA brings in additional information on point source inputs of manure and direct discharge of human waste into rivers. The MARINA model tracks the inputs of nutrients into rivers, the retention of nutrients in rivers (which impacts river water quality) and the potential release of nutrients into the ocean. An important difference of MARINA from Global NEWS is that MARINA is able to calculate the contribution of upstream, middlestream and downstream activities to the coastal water pollution (contributing to coastal eutrophciation).

For SDG 14.1.1a, the MARINA model will be used as the source of information for modelling the nutrient exports (of Nitrogen and Phosphate). MARINA can provide nutrient export from sub-basins to the river mouth (coastal waters) for countries that have the river mouths (these countries directly discharge nutrients to the coastal waters). For other counties (do not discharge directly to the coastal waters), MARINA can provide the information on the nutrient export by sub-basin that draing through those countries.

Additionally, UN Environment aims to work with partners to make geospatial data on the nutrient flows and the ICEP at river mouths will be made available every 5 years.

Level 1: Chlorophyll-A deviation modelling

Satellite-based assessments of ocean colour began in 1978 with the launch of the Coastal Zone Color Scanner (CZCS) aboard the NASA Nimbus 7 satellite. Following a decade long break in observations, there has been continuous satellite ocean colour since 1997 with SeaWiFS, followed by MERIS, MODIS (Terra, Aqua), VIIRS (NPP, N20) and now OLCI (S3-A, S3-B). Data gaps from individual sensors are common due to revisit cycles, cloud cover, and spurious retrievals resulting from a host of confounding atmospheric and aquatic conditions. This issue has been addressed by combining data from multiple sensors and creating a consistent, merged ocean colour product (e.g., chlorophyll-a). The ESA Ocean Colour CCI (OC_CCI) project, led by the Plymouth Marine Laboratory (PML), has produced a consistent, merged chlorophyll-a product from SeaWiFS, MODIS, MERIS and VIIRS, spanning 1997 to 2018 (Sathyendranath et al., 2018). A merged multi-sensor product will be updated in both time and with data from additional sensors (e.g., OLCI) under a forthcoming EUMETSAT initiative that will continue the time series on an operational basis.

As global satellite products are not validated in all locations or under all conditions, and more so what is ultimately desired here is to identify and assess relative changes in chlorophyll-a (as an indicator of eutrophication) vice absolute values, reporting will be done based on percentage derivation from a climatological baseline rather than numerical mg m^{-3} concentrations.

Generating Monthly Coastal Zone Chlorophyll-a

For SDG 14.1.1a, Chlorophyll-a (4 km resolution, monthly products) will be derived from the OC-CCI project is generated for each individual pixel within a country's Coastal Zone. For generation of a climatological baseline, results are averaged by month over the time period of 2000 – 2004.

Table 3: Example Monthly Coastal Zone Chl a.

Month	Pixel longitude	Pixel latitude	Monthly Average Chl a 2000	Monthly Average Chl a 2001	Monthly Average Chl a 2002	Monthly Average Chl a 2003	Monthly Average Chl a 2004	Baseline Chl a (average of 2000-2004)	2018 monthly average Chl a
Month	XXXX	XXXX	XX mg/m3	XX mg/m3	XX mg/m3	XX mg/m3	XX mg/m3	XX mg/m3	XX mg/m3

Calculating the Magnitude of Chlorophyll-a Deviations

Using the monthly baseline averages, the magnitude of deviation for the reporting period will be calculated as follows:

$$\text{Magnitude of } \textit{Chlorophyll-a} \text{ Deviation} = \frac{(\beta - \gamma)}{\beta} \times 100$$

Where β = the average monthly pixel chlorophyll-a 2000-2004

Where γ = the average monthly pixel chlorophyll-a for the reporting year

agnitude of deviation will be calculated by pixel and deamed a high deviation if the magnitude is more than 50% and as an extreme deviation at more than 100%. UN Environment and GEO BluePlanet are working to produce both a high deviation and extreme deviation map. For the purpose of the SDG 14.1.1, the 50% threshold in the high deviation will be used to calculate the percentage of the national EEZ with a deviation by month. The annual average of these monthly figures will also be provided.

Table 4: Example of Percentage of Coastal Zone with Chl a Deviations

Reporting year	Percentage of Pixels with High Deviation	Percentage of Pixels with Extreme Deviation
2018	XXXX	XXXX

Intra-annual coastal zone chloryphyll-A anomalies

An additional analysis intra-annual coastal zone chlorophyll-A anomalies is also suggested. This would provide an inter-annual perspective on bloom "events" in order to better captured changes against shorter time scales and a dynamic (moving) baseline. NOAA produces VIIRS chlorophyll-a anomaly products that are calculated using a running 61-day chlorophyll-a median following Stumpf et al. (2003). Based on this short-term dynamic baseline, two products are generated: 1) the difference anomaly (as in the original Stumpf protocol) and 2) the anomaly ratio which is the Chl-a difference anomaly normalized to the running 61-day median Chl-a. The difference anomaly is a reasonable indicator of local/coastal phytoplankton blooms while the anomaly ratio is a better indicator of blooms on a global scale and in areas that have relatively low biomass (i.e., a difference between 2 small values will be small in the absolute sense, but the ratio of 2 small values might indicate a substantial change). Because these anomalies are based on daily observations, data gaps due to cloud cover, sunglint and high sensor zenith angles are to be expected. Using daily data will introduce some bias due to seasonal and regional weather (e.g., cloud cover) patterns and should be considered during indicator reporting.

The frequency of intra-annual chlorophyll-a anomalies will be calculated as the number of days a pixel is calculated to have a high or extreme anomaly based on the number of days acceptable data is collected. Two frequencies will be used to assess the occurrences of anomalies: relative frequencies and cumulative frequencies. The relative frequency will be calculated as the frequency of a moderate, high or extreme anomaly based on the number of days with acceptable data collected and explains the proportion of times an anomaly is observed compared with the total number of valid observations. The cumulative frequency will be calculated based on the range of values associated with each level of anomaly (no anomaly, moderate, high and extreme), the frequency with which the anomalies occur, and the number of days with acceptable data collected. The cumulative frequency can be used as a visualization tool to show anomaly occurrences at a given location. UN Environment and GEO Blue Planet plan to make this available as supplementary information for this sub-indicator.

Using the daily anomaly occurrences at a given pixel, and the total number of days that valid data were collected, the relative frequency will be calculated as follows:

Relative Frequency of Pixel Chlorophyll-a Anomalies=β/γ

Where β = the number of days with a moderate, high or extreme anomaly

Where γ = the number of days valid observations

Using the daily anomaly data distribution ranging from no anomaly to an extreme anomaly, and the total number of days with acceptable data, the cumulative frequency can be calculated.

Level 2: In situ monitoring of nutrients

Where national capacity to do so exists, *national level* measurements of Chlorophyll-a and other parameters (including nitrogen, phosphate and silica) (*in situ* or from remote sensing), should be used to complement and ground truth global remote sensing and modelled data and enable a more detailed assessment of eutrophication. In particular, monitoring of supplementary eutrophication parameters is advisable to determine whether an increase in Chlorophyll-a concentration is directly linked to an anthropogenic increase in nutrients. Please refer to Table 2 for parameters for monitoring eutrophication at the national level (Level 2).

Level 2: National ICEP modelling

Existing ICEP modelling at the national level is limited, but could be further developed following the model of a current study analysing basin level data in Chinese rivers (Strokal *et al* 2016). The study utilises Global NEWS – 2 (Nutrient Export from WaterSheds) and NUtrient flows in Food chains, Environment and Resources use (NUFER) as models. The Global NEWS-2 model is basin-scale and quantifies river export of various nutrients (nitrogen, phorsphorus, carbon and silca) in multiple forms (dissolved inorganic, dissolved organic and particulate) as functions of human activities on land and basin characteristics (Strokal *et al* 2016). Furthermore, the model shows past and future trends. The NUFER model originally was established to quantify efficiencies in nutrient flows in the food chain and inform management options throughout the food chain. The study of Strokal et al 2016 develops the downscalled version (sub-basin scale) of Global NEWS. This level adds value because it can reveal nutrient issues in higher resolution, thus holding the potential to expose new hotspots. This could inform sub-basin-scale and innovative management approaches. In addition, the study couples these two models to better evaluate both point and diffuse nutrient sources.

Refining this same model at the national level could take into account more detailed information on livestock, fertilizer, sewage and various human activities. This would provide vital information to management approaches at a level that could implement action. Importantly, measuring and cataloguing the data from this model at a national level can further develop global understanding of nutrient pollution in oceans.

Indicator 14.1.1.b: Marine plastic debris

Background

Marine litter is found in all the world's oceans and seas. It constitutes an increasing risk to ecosystem health and biodiversity while entailing substantial economic costs through its impacts on public health, tourism, fishing and aquaculture. Marine plastics are of particular interest due to the fact that in the last 50 years, plastic production has increased more than 22-fold while the global recycling rate of plastics in 2015 was only an estimated 9%. This rise in plastic production and unmanaged plastic waste has resulted a growing threat to marine environments with an estimated 5-13 million tons of plastic from land-based sources ending up in marine environments .

Sources of plastics and microplastics to the ocean are many and varied, but the actual quantities involved remain largely unknown. Reliable quantitative comparisons between the input loads of macro and microplastics, their sources, originating sectors and users are not possible at present, and this represents a significant knowledge gap. Estimates of some sources, such as municipal solid waste, have been made. These are useful to focus attention, but the numbers should be treated with some caution due to the large uncertainties involved. How much of this material enters the ocean will be dependent largely on the extent and effectiveness of wastewater and solid waste collection and management.

There are large gaps in knowledge in terms of understanding marine plastics and microplastics: reliable figures for the volume of plastics entering the ocean, the accumulated volume of plastics in the marine environment, mapping of the source and sink location of plastics and basic data on microplastic are currently lacking. There is a need to use existing data from remote sensing, citizen science and in situ monitoring to better understand marine plastics and microplastics; however, much of the research in this field is at an initial stage and in many regions only data related to beach litter is available.

In the marine environment, as it relates to 14.1.1b, there are four fates for marine plastics and microplastics:

1) Washed onto beaches or shorelines (beach litter)

2) Floating on the water or in the water column

3) Deposited on the seafloor/seabed

4) Ingested by biota (e.g. sea birds).

The methodology for SDG 14.1.1b includes potential measurement of these four accumulation types; however, it is also important to note the importance of monitoring information on waste management and the sources of plastic pollution for understanding plastic pollution.

Proposed indicators for SDG reporting

The agreed indicator for marine plastic litter under SDG Target 14.1, as proposed by the IAEG-SDGs, is on marine plastic debris (14.1.1b). Based on the existing internationally agreed Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP)[4] guidelines and the existing national data collections, it is recommended that the SDG reporting includes sub-indicators related to beach litter, floating plastic and plastic in the sea column, plastic on the sea floor and additional option indicators. Indicators on micro-litter may also be considered as optional. The proposed global indicators are based on feasibility and relevance. All indicators described below are consistent with the GESAMP guidelines on monitoring marine plastics which were published in 2019. The GESAMP 2019 is an internationally agreed standard which was launch in March 2019, see: the *Guidelines for the Monitoring and Assessment of Plastic Litter in the Ocean,* https://environmentlive.unep.org/media/docs/marine_plastics/une_science_dvision_gesamp_reports.pdf)

Level 1: Proposed global indicators:

Plastic patches greater than 10 meters (for Areas Beyond National Jurisdiction or Total Oceans)

Beach litter originating from national land-based sources

Level 2: Proposed national indicators:

Beach litter count per km2 of coastline (surveys and citizen science data)

Floating plastic debris density (visual observation, manta trawls)

Water column plastic density (demersal trawls)

Seafloor litter density (benthic trawls (e.g. fish survey trawls), divers, video/camera tows, submersibles, remotely operated vehicles)

Level 3: Supplementary indicators:

These are listed in the table below for information, but are not described in detail in this manual.

[4] More information on the UN Group of Experts on the Scientific Aspects of Marine Environmental Protection can be found here http://www.gesamp.org/. GESAMP is a collaboration of the UN System. The GESAMP working group 40 focuses on marine litter and then and involved experts on marine litter. The GESAMP 2019 wasa produced under working group 40. See: https://environmentlive.unep.org/media/docs/marine_plastics/une_science_dvision_gesamp_reports.pdf)

Table 5: Monitoring parameters for marine plastic litter to track progress against SDG Indicator 14.1.1b.

Monitoring parameters (and methods)	Level 1	Level 2	Level 3
Plastic patches greater than 10 meters*	X		
Beach litter originating from national land-based sources	X		
Beach litter (beach surveys)		X	
Floating plastics (visual observation, manta trawls)		X	
Water column plastics (demersal trawls)		X	
Seafloor litter (benthic trawls (e.g. fish survey trawls), divers, video/camera tows, submersibles, remotely operated vehicles)		X	
Beach litter microplastics (beach samples)			X
Floating microplastics (manta trawls, e.g. Continuous Plankton Recorder)			X
Water column microplastics (demersal plankton trawls)			X
Seafloor litter microplastics (sediment samples)			X
Plastic ingestion by biota (e.g. birds, turtles, fish)			X
Plastic litter in nests			X
Entanglement (e.g. marine mammals, birds)			X
Plastic pollution potential (based on the use and landfilling of plastics)			X
River litter			X
Other parameters related to plastic consumption and recycling			X
Health indicators (human health and ecosystem health)			X

** This indicator is most useful for areas beyond national jurisdiction or total ocean area, not for national monitoring.*

These indicators are marked as levels 1, 2 or 3, level 1 being global data or globally modelled, level 2 including national monitoring and level 3 describing supplementary/recommended indicators.

Step-by-step guide to implementing the indicator

Level 1: Plastic patches greater than 10 meters

Satellite-based global data products make up the statistics for this indicator. NASA and ESA both contribute satellite images to construct information on the plastic patches greater than 10 meters throughout the world's oceans. Multi-spectral satellite remote sensing of plastic in the water column is currently only possible for larger elements (more than 10m) and under good atmospheric conditions (no clouds).

There are some promising methods looking at anomalies or particular signatures to identify ocean plastic. For example ESA's Sentinel-3 satellite has an ocean color imager that is potentially detecting unique signatures or large agglomerations of plastic. However, this type of analysis is new. The applicability of this sub-indicator is considered within the scope of the SDG for discussion, but is most relevant for areas beyond national jurisdiction and not ot create national level indicators.

Level 1: Beach litter originating from national land-based sources

Modelling of litter movement through the oceans occurs through numerical models using inputs including ocean flow and marine plastic litter characteristics. UN Environment and Florida State are producing a global model of marine litter using OceanParcels v2.0, a state-of-the-art Lagrangian Ocean analysis framework to create customizable particle tracking simulation using outputs from ocean circulation models. The ocean circulation model outputs used here are from the GOFS3.1, a global ocean forecast system based on the HYbrid Coordinate Ocean Model (HYCOM) and the Navy Coupled Ocean Data Assimilation (NCODA). NCODA uses the 24-hour model forecast as a first guess in a 3D variational scheme and assimilates available satellite altimeter observations, satellite, and in-situ sea surface temperature as well as in-situ vertical temperature and salinity profiles from XBTs, Argo floats and moored buoys. Surface information is projected downward into the water column using Improved Synthetic Ocean Profiles (Helber et al., 2013). The horizontal resolution and output frequency for the GOF3.1 outputs are 1/12° (8 km at the equator, 6 km at mid-latitudes) and 3-hourly, respectively.

OceanParcels v2.0 is a Lagrangian ocean analysis framework designed to combine (1) a wide flexibility to model particles of different natures and (2) an efficient implementation in accordance with modern computing infrastructure. The latest version includes a set of interpolation schemes to read various types of discretized fields, from rectilinear to curvilinear grids in the horizontal direction, from z- to s- levels in the vertical and different variable distributions such as the Arakawa's A-, B- and C- grids (Delandmeter and van Sebille, 2019).

The primary challenge of modeling the global displacement of marine litter is the large uncertainties associated with the amount and location of mismanaged plastic waste (MPW) entering the ocean. A zero-order estimate is provided by Jambeck et al. (2015) who estimated the total amount of plastic waste generated by 192 coastal countries to be 275 million metric tons (MT) of plastic waste, with 4.8 to 12.7 million MT entering the ocean in 2010. This data was used to seed the model which is proposed for use for SDG 14.1.1b. This was used to estimate where plastics that would be found on the coast likely originated from. As a simple example, for Kenya, based on this model, of the plastic which ends up on Kenya's beaches, 11% likely originated from Kenya, 60% likely came from countries in Africa and 29% likely came from outside the region. This model can be produced annually and updated as better waste emissions data becomes available for countries.

Level 2: Beach litter (average count of plastic items per km2)

Methodology: Beach litter surveys following the UN Environment/IOC-UNESCO operational guidelines[5] (Cheshire et al. 2009) and GESAMP Guidelines (GESAMP 2019)

Step one Identify the national authority responsible for gathering data and reporting on marine pollution and the agency/organisation responsible for implementing beach litter surveys.

Step two Explore the use of existing data which is being collected by citizen science initiatives and beach clean ups.

Step two Conduct beach litter surveys following the UN Environment/IOC-UNESCO operational guidelines, which are provided in Appendix 4 and using resources from the GESAMP Guidelines (GESAMP 2019).

National efforts to collect data on beach litter can be supported by campaigns to engage members of the public as volunteers in beach clean-ups (see for example the Ocean Conservancy's International Coastal Clean-up (ICC) initiative[6]) or citizen science programmes (see for example NOAA's Marine

[5] The UN Environment/IOC-UNESCO methodology for comprehensive beach surveys has been developed with reference to a number of existing survey protocols, including OSPAR and NOWPAP protocols.

[6] Ocean Conservancy International Coastal Clean-up initiative: https://oceanconservancy.org/trash-free-seas/international-coastal-cleanup/

Debris Monitoring and Assessment Citizen Science Project[7]). Specific instructions on how to conduct citizen science beach surveys are included in the GESAMP Guidelines (GESAMP 2019). They provide resources on previous citizen science projects and guidance for ensuring sound data collection and management with citizen science.

Beyond the tools used to conduct beach litter monitoring, it is important to consider the timing of surveys in order to properly plan effective surveys. The GESAMP Guidelines explain two main types of surveying beaches including rapid assessment surveys and routine shoreline monitoring. Rapid assessment surveys are best conducted in response to natural disasters, to build a baseline for future surveys and/or to identify beach litter hotspots. Routine shoreline monitoring is also important because it provides insight to beach litter accumulation in a particular location. It is best to identify national needs and then define the approach to accommodate those needs (GESAMP 2019).

Beach litter is an important parameter that all countries should monitor and report on. Where in-country capacity or opportunities exist to conduct more extensive marine litter monitoring, countries can also conduct surveys of floating plastics, plastics on the seafloor or microplastics (as described below).

Level 2: Floating plastics (average count of plastic items per km2)

Methodology: GESAMP Guidelines (GESAMP 2019)

Step one — Identify the national authority responsible for gathering data and reporting on marine pollution and the agency/organisation responsible for monitoring floating plastics.

Step two — Work with planning authority to understand local needs and determine the best monitoring approach. Descriptions of various approaches from the GESAMP Guidelines are listed in Table 8 adapted from the GESAMP Guidelines.

Table 6: Monitoring methods for floating plastics

Method	Description	Advantages	Limitations	Examples of use
Net tows	Floating plastics can be sampled using a specific net with wings built to keep it on the surface.	Easily deployed from small to large vessels Underway sampling Use of flow meter to estimate volume	Weather dependant Prone to contamination Volume of water filtered can only be estimated with flow meter Towing speed and time are limited due to potential net clogging and under-sampling surface waters Materials smaller than the net mesh are lost	Viršek *et al* (2016) Lebreton *et al* (2018)

[7] NOAA Marine Debris Monitoring and Assessment Citizen Science Project: https://marinedebris.noaa.gov/research/marine-debris-monitoring-and-assessment-project

Mega net	Large net to capture larger litter than standard nets	Captures macro and meso litter	Weather dependent Due to the size, the requirements to use the net are great	Lebreton *et al* (2018)
Bulk water sample	Sampling large volume of water and volume reducing	Known volume sample It is possible to sample from vessels of opportunity	Litter fractions are small because the volume that can be processed is limited May be prone to contamination	Song *et al* (2014)
Visual observations from a ship	Surveyors identify floating marine litter from a vessel Use either fixed width transects (assuming all litter seen) or distance sampling (corrects for decrease in detection probability with distance from vessel)	Easy to do from vessels of opportunity Low cost and low equipment requirements	Limited in location because can only survey near the vessel Biased based on what is easily visible Prone to error based on experience of the surveyor	Ryan (2013)
Photographic and aerial surveys	Visual survey of floating marine litter from an airplane or drone	Cover large areas Good for mega-litter	High cost and high equipment requirements Limited to macro and mega plastics Biased based on what is easily visible by the equipment	Lebreton *et al* (2018)

Level 2: Water column plastics (average count of plastic items per km3)

Methodology: GESAMP Guidelines[8] (GESAMP 2019)

[8] GESAMP (2019). Guidelines or the monitoring and assessment of plastic litter and microplastics in the ocean (Kershaw P.J., Turra A. and Galgani F. editors), (IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP/ISA Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). Rep. Stud. GESAMP No. 99, 130p
https://environmentlive.unep.org/media/docs/marine_plastics/une_science_dvision_gesamp_reports.pdf

Step one Identify the national authority responsible for gathering data and reporting on marine pollution and the agency/organisation responsible for monitoring water column plastics.

Step two Work with planning authority to understand local needs and determine the best monitoring approach. Descriptions of various approachs from the GESAMP Guidelines are listed in Table 9 adapted from the GESAMP Guidelines.

Table 7: Monitoring methods for water column plastics

Method	Description	Advantages	Limitations	Examples of use
Bongo nets or horizontally hauled plankton nets	Nets used for surveying the mid-water region in samples	Easily deployable from vessels Applicable at various depths Use of flow meter to estimate volume Not weather dependent Paired with other nets for multiple sampling	Prone to contamination, particularly in sample collection on the vessel Under identifies materials smaller than the mesh Vessel speed may be restricted	Doyle *et al* (2011)
Underway pumps	Utilizing seawater intakes from vessels	Ability to sample a known volume of water over a given time or distance Easily controls for contamination on vessel	The size range of litter identified is limited The sea state can impact results Prone to contamination from sampling apparatus	Desforges *et al* (2014) Lusher *et al* (2014)
Submersible pumps	Deck pump lowered to a known depth	Known volume of water sampled	The size range of litter identified is limited The vessel must be stationary	Setälä *et al* (2016)
Bulk sample	Sampling large volume of water and volume reducing	Known volume of water sampled	Prone to contamination on deck	Song *et al* (2014)
CPR	Continuous plankton recorder towed from ships underway In use since 1946	Ability to use for a large distance and from vessels of opportunity Ability to compare to archived samples	Risk of underestimating larger particles due to intake size	Thompson *et al* (2004)
Fisheries observer	Ability to be opportunistic by capturing marine litter samples using pelagic	No equipment required Observing long line fisheries that capture mostly	Dependent on fisheries reporting litter Unsystematic and not specific	Uhrin (2018)

	fishing gear	nets and line	to a selected area	

Level 2: Seafloor litter (average count of plastic items per km2)

Methodology: GESAMP Guidelines[9] (GESAMP 2019)

Step one Identify the national authority responsible for gathering data and reporting on marine pollution and the agency/organisation responsible for monitoring seafloor litter.

Step two Work with planning authority to understand local needs and determine the best monitoring approach. Descriptions of various approachs from the GESAMP Guidelines are listed in Table 10 adapted from the GESAMP Guidelines.

Table 8: Monitoring methods for seafloor litter

Method	Description	Advantages	Limitations	Examples of use
Shallow water/diving	Divers or snorklers visually idenfity marine litter	Ability to be opportunistic by using ongoing biodiversity programmes or other existing surveys	Biased based on what is easily visible Limited locations and size of area sampled	Spengler and Costa (2008)
Trawling	Collection/ stratified sampling or fishing nets Collection/ Pole trawling	Good for deeper waters and large-scale evaluation Opportunity to use on-going fish stock assessments	Topography of seafloor may lead to underestimation Bottom trawling has a significant impact of benthic ecosystems	Spengler and Costa (2008)
ROVs	Remotely operated vehicles used to survey the seafloor	Good for continental slopes, uneven terrain and deep seafloor	High equipment costs Limited size of area sampled	Bergmann and Klages (2012) Miyake *et al* (2011) Tekman *et al* (2017) Chiba *et al* (2018)

[9] GESAMP (2019). Guidelines or the monitoring and assessment of plastic litter and microplastics in the ocean (Kershaw P.J., Turra A. and Galgani F. editors), (IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP/ISA Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). Rep. Stud. GESAMP No. 99, 130p https://environmentlive.unep.org/media/docs/marine_plastics/une_science_dvision_gesamp_reports.pdf

Indicator 14.2.1: Number of countries using ecosystem-based approaches to manage marine areas

Target 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

Background

From an ecological perspective, ecosystem approaches consider the connections between the living organisms, habitats, physical and chemical conditions within an ecosystem, focusing on the importance of ecological integrity, biodiversity and overall ecosystem health. From a management perspective, ecosystem-based approaches refer to integrated management strategies for socio-ecological systems that consider ecological, social and economic factors and apply principles of sustainable development. These different ways of interpreting the 'ecosystem-based approach' are reflected in existing indicators. A review of these indicators and their underlying methodologies shows two ways in which Regional Seas Programmes and other key intergovernmental, international or regional bodies are monitoring and assessing the implementation of ecosystem-based approaches.

Proposed indicators for SDG reporting

Regional Seas Coordinated Indicator 22 'Integrated Coastal Zone Management (ICZM) is proposed as the primary indicator. For countries with Marine/Maritime Spatial Planning (MSP) in place, these plans can be helpful to assess ICZM. For other countries, it is important to identify ways to measure existing plans and to build capacity for integrated planning. All data for this indicator will be based on country submissions to the Regional Seas Programme. As monitoring will not be done through globally derived products, no level 1 indicator is proposed/ OR only level 2 and level 3 indicators are proposed.

In order to promote the use of the Regional Seas as part of the follow-up and review mechanism for the Regional Seas, UNEP drafted report on how Regional Seas data could be directly used for the SDGs (see https://wedocs.unep.org/bitstream/handle/20.500.11822/27295/ocean_SDG.pdf?sequence=1&isAllowed=y).

Level 2: Proposed national indicators:

Number of countries using ecosystem-based approaches to manage marine areas (measured through ICZM (Integrated Coastal Zone Management), marine spatial plan or other area-based, integrated planning and management in place)

Level 3: Supplementary indicators:

These are described in the table below for information, but this manual does not go into detail

Table 9: Monitoring parameters for implementation of the ecosystem-approach to track progress against SDG Target 14.2.

Monitoring parameters	Level 2	Level 3
Number of countries using ecosystem-based approaches to manage marine areas (measured through ICZM (Integrated Coastal Zone Management), marine spatial plan or other area-based, integrated planning and management in place)	X	
Ecological parameters (e.g. state of biodiversity, water quality, habitat quality, ecosystem health)		X

These indicators are marked as levels 1, 2 or 3, level 1 being global data or globally modelled, level 2 including national monitoring and level 3 describing all other parameters.

Step-by-step guide to implementing the indicator

Level 2: Ecosystem-based approaches to manage marine areas in place

This indicator aims to capture ICZM and other area-based, integrated planning and management in place in waters under national jurisdiction, including exclusive economic zones (e.g. marine/maritime spatial planning, marine protected areas, marine zoning, sector specific management plans)

Step one Identify national authorities/agencies/organisations responsible for coastal and marine/maritime planning and management.

Step two Identify and spatially map the boundaries of ICZM plans or other plans at national, sub-national and local level. Coordinate with the national authorities/agencies/organisations responsible for coastal and marine/maritime planning and management to complete a questionnaire on the ICZM plans (Shipman and Petit 2014)).

Step three Determine the status of implementation of each plan, and categorise the spatial map according to implementation stages:

1) Initial plan preparation
2) Plan development
3) Plan adoption/designation
4) Implementation and adaptive management

Collect the questionnaire responses and document the answers to include with the spatial map as reporting for this indicator.

The spatial map showing the boundaries of relevant plans (produced in step two) could also be used to calculate the proportion of national waters, or national exclusive economic zone, covered by relevant plans. This can be done by overlaying the spatial layer of relevant plans with a spatial layer of national waters, or of the exclusive economic zone, to identify where the two layers coincide (following a similar methodology to calculating marine protected area coverage for SDG Indicator 14.5.1 described in the relevant chapter).

Ideally, all countries should report on the spatial boundaries of their relevant plans, including the implementation stage. However, at a minimum information on if a plan is in place should be collected.

It is advised that all policy changes are reported on annually and, in addition, that a review of changes in laws be conducted as an assessment to provide context on the state of environmental reporting in a 5-10 year reporting cycle.

An additional tool for national planning for oceans includes ocean accounting (UN-ESCAP 2018). These would be an expansion of existing tools known as System of Environmental Economic Accounting – Experimental Ecosystem Accounting (SEEA-EEA) (SEEA 2017) and would be compiled for national territories with the possibility to provide regional and global data for international waters/high seas. These accounts can also be compiled at the sub-national level for example at a specific coastline or bay. The components of oceans accounts include drivers, assets (including extent and condition), ocean services (including quantity and value) and governance (such as management practices) (UN-ESCAP 2018).

Level 3: Ecological parameters (e.g. state of biodiversity, water quality, habitat quality, ecosystem health)

Monitoring ecological parameters in addition to ecosystem-based management is useful to inform the effectiveness of management practices. Understanding the state of biodiversity, water quality, habitat quality, ecosystem health and other ecological parameters can reveal disturbances in ocean health that may have otherwise been overlooked. These disturbances can then be addressed in future management and planning.

Indicator 14.5.1: Coverage of protected areas in relation to marine areas

Target 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

Background

The protection of marine areas is essential for protecting the oceans biodiversity and natural resources. The importance of protection was recognized in the MDGs and has been recognised in the SDGs. Due to the fact that the measurement of marine protected areas is well established, this section of the report will not go into detail on the measurement of marine protected areas, but will instead proposes some additional aspects of target 14.5 which might be considered for monitoring.

Proposed indicators for SDG reporting

The agreed indicator for SDG Target 14.5, as proposed by the IAEG-SDGs, is 'Coverage of protected areas in relation to marine areas' (14.5.1). This indicator is classified as tier 1, meaning that data and methodology are internationally established and available globally. Many countries already collect and manage data on the coverage of coastal and marine areas by marine protected areas, including the underlying geographic datasets. These data are largely curated by relevant Ministries (e.g. of the Environment) or National Park Agencies. The national data (including boundary data in a GIS format, along with associated ancilliary information such as MPA name, reported surface area, name of the management authority, etc.) are reported by the relevant authorities to the World Database on Protected Areas (WDPA)[10], a global authoritative database curated by UNEP-WCMC, with support from IUCN. Using the information in the WDPA, national-level statistics can be produced on protected area coverage for every country and territory, on a monthly basis. A more detailed description of the concepts, methodology and data sources for the indicator is provided by the SDG 14.5.1 metadata[11], available from the SDG indicators metadata repository[12]. As this cannot be monitored through global monitoring, level 1 and 2 are combined into a single level.

Level 1/2: Proposed global indicators:

Coverage of marine and coastal areas by protected areas

Level 3: Proposed national indicators:

Coverage, by protected areas, of areas of importance for biodiversity and derived ecosystem services
Management effectiveness of protected areas
Connectivity of protected areas
Equity in protected area benefits and costs

Table 10 Monitoring parameters to track progress against SDG Target 14.5. Note: the list of parameters in this table is not exhaustive.

Monitoring parameters	Level 2	Level 3
Coverage of marine and coastal areas by protected areas	X	

[10] UNEP-WCMC and IUCN 2018. Protected Planet: The World Database on Protected Areas (WDPA) [Online], Cambridge, UK: UNEP-WCMC and IUCN. Available at: www.protectedplanet.net

[11] SDG Indicator 14.5.1 metadata: https://unstats.un.org/sdgs/metadata/files/Metadata-14-05-01.pdf

[12] SDG indicators metadata repository: https://unstats.un.org/sdgs/metadata/

Coverage, by protected areas, of areas of importance for biodiversity and derived ecosystem services		X
Management effectiveness of protected areas		X
Connectivity of protected areas		X
Equity in protected area benefits and costs		X

These indicators are marked as levels 1, 2 or 3, level 1 being global data or globally modelled, level 2 including national monitoring and level 3 describing all other parameters.

Step-by-step guide to implementing the indicator

Level 1/2: Coverage of marine and coastal areas by protected areas

Countries that are already regularly reporting national data on marine protected areas to the WDPA do not need to take further action towards reporting against SDG Indicator 14.5.1. Using data reported by the relevant authorities, UNEP-WCMC calculates national-level statistics on the coverage of coastal and marine areas by MPAs, and makes the information available to the UN Statistics Division at their request. Countries can view the national-level statistics produced using the WDPA via the Protected Planet website[13], where details of the step-by-step methodology for calculating national protected area coverage can also be accessed[14] (see also Text Box 6).

Countries that are not yet, or irregularly reporting their national data to the WDPA are encouraged to do so, according to the data submission guidelines available in the WDPA User Manual[15]. All countries, via the WDPA, should report on coverage of marine and coastal areas by protected areas as a key parameter. Where in-country capacity or opportunities exist, countries can also assess supplementary parameters to address other elements of SDG Target 14.5 (described in the following section). Please refer to Table 12 for parameters for monitoring progress towards SDG Target 14.5.

Text Box 6: Calculation of marine protected area coverage (WDPA methodology):
When calculating protected area coverage, answers to the following questions will have a major influence on the resulting coverage statistics:

1) What is a protected area?
When calculating protected area coverage, UNEP-WCMC only uses sites that have been reported as meeting the IUCN definition of protected area[16] and/or that of the Convention on Biological Diversity[17]. For more information on protected areas, see the dedicated page on the Biodiversity a to z[18].

2) What protected areas data are used?
UNEP-WCMC does not include all sites in the WDPA in protected area coverage calculations.

[13] See: www.protectedplanet.net/c/unep-regions

[14] WDPA methodology for calculating protected area coverage: www.protectedplanet.net/c/calculating-protected-area-coverage

[15] See: www.wcmc.io/WDPA_Manual

[16] IUCN definition of protected area: "a clearly defined 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" (Dudley, N. (ed.) 2008. Guidelines for Applying Protected Area Management Categories. IUCN: Gland, Switzerland. p.8-9)

[17] CBD definition of protected area: *a geographically defined area, which is designated or regulated and managed to achieve specific conservation objectives* (Art. 2 of the Convention on Biological Diversity)

[18] Biodiversity a to z: protected areas: http://www.biodiversitya-z.org/content/protected-area

"Proposed" protected areas are excluded, as are sites submitted as points with no reported area. Currently UNESCO Man and Biosphere Reserves (MAB)[19] are excluded, on the basis that that the MAB sites currently in the WDPA include buffer and transition zones that in many cases are not protected areas (MAB Core areas usually coincide with protected areas designated at a national level and are therefore generally accounted for in the calculations). In cases where data providers request that their data are not shared, UNEP-WCMC uses these data to calculate coverage statistics, but does not make them available through the Protected Planet website.

3) Which base map (coastline) layer is used?
UNEP-WCMC uses a custom-designed dataset combining exclusive economic zones and terrestrial country boundaries, a simplified version of which has been published by Brooks et al. (2016)[20]. This may differ from the more detailed national base layers used by countries to generate their own statistics. Therefore, there is an acknowledged potential for the results to differ slightly from those produced by countries.

Level 3: Other elements of Target 14.5

Coverage, by protected areas, of areas of importance for biodiversity

Protected area coverage alone does not give a full indication of the importance of an area in terms of biodiversity (and derived ecosystem services), for example the diversity of species that have been protected or the number of people who are benefiting from the protected area (Gill et al. 2017). As such, a calculation of the relative coverage, by protected areas, of those marine areas which are of particular importance for biodiversity (and derived ecosystem services) is a useful approach to assess the comprehensiveness and value of an MPA network.

The first step, in such a calculation, is to determine which areas are of importance for biodiversity. A number of different attributes can be considered when defining areas of biodiversity importance. Table 13 presents the attributes included in some of the most widely used, internationally recognised prioritisation (via criteria) schemes for conservation. These schemes also offer spatial data layers to allow locating these areas on the ground. Countries may choose to select one or multiple schemes from this list, or they may define their own national criteria for biodiversity importance. Then and depending on available data, information and knowledge, a spatial layer can be created that shows areas considered to be important for biodiversity (and derived ecosystem services).

Table 11: A summary of attributes of biodiversity importance included in widely known and used prioritisation schemes for conservation (abbreviations are explained below the table). (Adapted from: Dunn et al. (2014) The Convention on Biological Diversity's Ecologically or Biologically Significant Areas: Origins, development, and current status).

	EBSA	VME	PSSA	WHS	Ramsar	IBA	KBA	Natura 2000	AZE Sites
Uniqueness or rarity	✔	✔	✔	✔	✔	✔	✔	✔	✔
Special importance for life history stages of species	✔	✔	✔	✔	✔	✔	✔	✔	✔
Importance to threatened or endangered species	✔	✔	✔	✔	✔	✔	✔	✔	✔

[19] Protected Planet description of UNESCO Man and Biosphere Reserves: https://www.protectedplanet.net/c/world-database-on-protected-areas/internationally-designated-protected-areas/man-and-the-biosphere-reserves

[20] Data from Brooks et al. 2016: http://datadryad.org/resource/doi:10.5061/dryad.6gb90.2

Vulnerability, fragility, sensitivity or slow recovery	✔	✔	✔	X	?	X	✔	?	X
Productivity	✔	X	✔	✔	X	X	✔	X	X
Biodiversity	✔	X	✔	✔	✔	X	?	X	X
Naturalness	✔	X	✔	✔	✔	X	✔	X	X
Structure	X	✔	✔	X	X	X	?	X	X
Historical geomorphological importance	X	X	X	✔	X	X	X	X	X

Acronyms – explanation and relevant policy instrument/organisation
EBSA: Ecologically or Biologically Significant marine Areas – Convention on Biological Diversity (CBD)
VME: Vulnerable Marine Ecosystem – UN Food and Agriculture Organisation (FAO)
PSSA: Particularly Sensitive Sea Area – International Maritime Organisation (IMO)
WHS: World Heritage Site – UN Educational, Scientific and Cultural Organisation (UNESCO)
Ramsar: Ramsar Sites (Wetlands of International Importance) – Convention on Wetlands of International Importance (Ramsar Convention)
IBA: Important Bird and Biodiversity Areas – BirdLife International
KBA: Key Biodiversity Areas – International Union for Conservation of Nature (IUCN), BirdLife International, PlantLife International, Conservation International, Critical Ecosystem Partnership Fund and others (Note: KBAs include IBAs and AZE Sites)
Natura 2000: European network of protected sites under the European Habitats and Birds Directives – European Union
AZE Sites: Alliance for Zero Extinction Sites – Alliance for Zero Extinction

The second step is to calculate the relative coverage, by protected areas, of areas of biodiversity importance. This is done by overlaying the spatial layer of areas of biodiversity importance with the spatial layer of protected areas, in the national waters of the country. The results can be represented on a map or as a graph showing trends in relative coverage over time. This approach is already being used, at the global scale, for tracking progress against Aichi Target 11 of the UN Strategic Plan for Biodiversity (2010-2020), using the indicator "Protected Area Coverage of Key Biodiversity Areas"[21].

Management effectiveness of protected areas

The designation of a protected area does not necessarily ensure that conservation objectives are met, or that they have even been set and documented as part of a management plan. Effective management is essential to ensure that a protected area achieves the intended benefits for biodiversity and ecosystem services. A number of well-recognised mechanisms for assessing management effectiveness of protected areas exist, for example from IUCN (Hockings et al. 2006). One current approach to assess, at the global scale, the status and trends in effectiveness of management of protected areas is the Aichi 11 indicator "Protected Areas Management Effectiveness"[22], which records the number and area of assessments of management effectiveness completed by countries, and the overall management effectiveness score for each aspect of management.

[21] https://www.bipindicators.net/indicators/protected-area-coverage-of-key-biodiversity-areas. Note that information on the applicability of this approach in the context of the SDGs is available in the SDG 14.5.1 metadata (https://unstats.un.org/sdgs/metadata/files/Metadata-14-05-01.pdf).

[22] https://www.bipindicators.net/indicators/protected-area-management-effectiveness

Findings on the bigger picture of SDG 14 – from national implementation to global monitoring

Implementing SDG indicators at country level

The *Global Manual on Ocean Statistics* is intended to support countries in their efforts to implement indicators for tracking progress against SDG 14. The country missions to Fiji and Colombia highlighted that countries start off from different contexts, and face different challenges, in implementing the SDG indicators. Some countries, like Colombia, already have centralised data gathering systems and/or national indicators in place that can be built on to implement the SDG indicators. In contrast, Fiji and other Pacific island nations are only just starting to address the SDG targets and indicators at country level; here, the SDG process is mainly being driven forward at the regional level by the Pacific Regional Seas Programme and other regional institutions. One common challenge that countries in both regions share is limited funds and capacity for monitoring programmes.

The recommendation that can be drawn from these country insights is that, where possible, the implementation of indicators for SDG 14 should be aligned with, and build on, existing national and regional monitoring programmes and indicators, so as to optimise the use of limited available resources. The Regional Seas Programmes are well placed in supporting countries to identify these synergies, and find efficient ways of implementing the SDG indicators.

Coordinated international monitoring of transboundary issues

As mentioned in the introduction to the *Global Manual*, many issues remain to be resolved in order to achieve more complete global monitoring of transboundary marine issues, including in areas beyond national jurisdiction. This will require countries to work together in a coordinated effort using both satellite remote sensing and *in situ* international surveys, including shared data collection protocols, good data sharing practices, innovative and cost-effective sampling methodologies. The Regional Seas Programmes are working towards coherent and coordinated monitoring approaches within, as well as across, regional seas, and could play an important role in facilitating coordinated international monitoring efforts.

Globally applicable methodologies to track global progress

Finally, the *Global Manual* recognises that the agreed SDG and alternative indicators only capture part of the associated SDG targets. In the long-term, these limitations will have to be addressed to ensure that SDG 14 is fully met. In the meantime, however, it is important to focus on what can be realistically achieved by all countries, so that data can be meaningfully aggregated to give a global picture of progress towards SDG 14. The *Global Manual on Ocean Statistics* aims to support this effort by providing step-by-step indicator methodologies that require minimum resources and technical capacity, can be integrated with existing national and regional approaches, and provide the minimum parameters required to monitor progress against SDG Targets 14.1, 14.2 and 14.5.

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The following appendices are provided as separate documents:

Appendix 1: Summary tables of existing indicator compilation (Regional Seas Programmes)

(attached as an additional word document)

Appendix 2: Summary of regional seas and other relevant data collection efforts

SDG Indicator 14.1.1a

A review of existing indicators and methodologies currently used by Regional Seas Programmes and other key intergovernmental, international or regional bodies highlights three main approaches for monitoring coastal eutrophication.

1) Indicators for the cause of eutrophication (nutrient input and concentrations): Coastal eutrophication is mainly caused by nutrient enrichment of coastal environments. Nutrient enrichment is a direct consequence of nutrient inputs from land-based (and atmospheric) sources, in particular phosphorous and nitrogen run-off from agricultural fertilisers, livestock waste and domestic wastewater. Five Regional Seas Programmes[23], as well as the European Union (EU) Marine Strategy Framework Directive (MSFD, subsequently referred to as "Marine Directive"), include input and concentrations of nutrients (nitrogen and phosphorous) as indicators or assessment criteria for eutrophication. Nutrient concentrations are measured from *in situ* water samples using colorimetric, fluorometric and UV spectrometric methods (for information about sampling and measuring methods for nutrients, see for example OSPAR's eutrophication monitoring guideline on nutrients (OSPAR 2013a)).

2) Indicators for the direct effects of eutrophication (e.g. Chlorophyll-a concentrations, biomass growth, water clarity/turbidity): Nutrient enrichment of coastal waters causes excessive growth of plants, algae and phytoplankton. This can be monitored by measuring the abundance of indicator species, the clarity or turbidity of the water, or Chlorophyll-a concentrations. Chlorophyll-a is a pigment contained in plants, algae and phytoplankton that can be used to measure biomass levels, thus providing an alternative indicator for eutrophication. Chlorophyll-a is the most frequently used indicator/assessment criterion for eutrophication (or primary productivity) across the 18 Regional Seas Programmes[24]. In addition, the European Environment Agency, the EU Marine Directive, the United States National Oceanic and Atmospheric Administration (NOAA) and the Global Environment Facility Transboundary Waters Assessment Programme (GEF-TWAP) also use Chlorophyll-a as indicator for eutrophication (or primary productivity).

[23] Regional Seas Programmes that use input and concentrations of nutrients as indicator for eutrophication: OSPAR (Northeast Atlantic), HELCOM (Baltic Sea), UNEP-MAP (Mediterranean Sea), CPPS (Southeast Pacific) and NOWPAP (Northwest Pacific)

[24] Regional Seas Programmes that use Chlorophyll-a as indicator for eutrophication: OSPAR (Northeast Atlantic), HELCOM (Baltic Sea), UNEP-MAP (Mediterranean Sea), Nairobi Convention (Western Indian Ocean), NOWPAP (Northwest Pacific), (ROMPE sea area), PERSGA (Red Sea and Gulf of Aden) and CPPS (Southeast Pacific)

Regional Seas Programmes use two methodological approaches for monitoring Chlorophyll-a:

1) *In situ* measurements, and
2) Remote sensing using satellite images.

In situ measurements can be obtained from ships carrying measuring devices (e.g. the Continuous Plankton Recorder[25]), or from moorings, buoys and autonomous underwater vehicles equipped with sensors. Setting up Chlorophyll-a observatories, where these are not already in place, requires considerable technological and resource capacity. One way of reducing the costs of *in situ* measurements is to use ships of opportunity, such as commercial vessels or ferries. A less resource intensive alternative to *in situ* measurements is to monitor Chlorophyll-a using satellite remote sensing. Remote sensing also enables larger temporal and spatial coverage, compared to *in situ* methods, for example providing daily snapshots of an area of approximately 500 metres. Remote sensing can also be coupled with modelling, allowing to fill gaps in satellite data that might be caused, for example, by cloud cover. An example of remote sensing technology applied is the Northwest Pacific Action Plan Eutrophication Assessment Tool (NEAT), which is a satellite imagery technique for detection of potential dead zones in the sea. The Regional Seas Programme's Northwest Pacific Action Plan will collaborate with Google and the Japan Aerospace Exploration Agency to test NEAT to monitor eutrophication by monitoring chlorophyll-a concentration levels and trends in oceans around the world with cloud computing (Liu 2019).[26]

3) Indicators for the indirect effects of eutrophication (e.g. dissolved oxygen levels): Lastly, four Regional Seas Programmes[27] and the EU Marine Directive use dissolved oxygen levels in the water as an additional indicator for eutrophication. Oxygen depletion (hypoxia or anoxia) is an indirect effect of nutrient enrichment caused by bacterial decomposition of large amounts of dead plants and algae. Dissolved oxygen levels can be determined from water samples using electrochemical or optical sensors (see for example OSPAR's eutrophication monitoring guideline for oxygen (OSPAR 2013b).

The eutrophication indicators related to these methodologies are summarised in Table 3.

Table 12: Summary of eutrophication indicators and assessment criteria currently used by Regional Seas Programmes and other key intergovernmental, international or regional bodies. (Note: indicators in italics are not explicitly for eutrophication) (CPPS: Permanent Commission for the South Pacific (Southeast Pacific); EU MSFD: European Union Marine Strategy Framework Directive; EU WFD: European Union Water Framework Directive; GEF-TWAP: Global Environment Facility Transboundary Waters Assessment Programme; HELCOM: Helsinki Commission (Baltic Sea); Nairobi Convention (Western Indian Ocean); NOAA: National Oceanic and Atmospheric Administration; NOWPAP: Northwest Pacific Action Plan (Northwest Pacific); OSPAR: Oslo-Paris Convention (Northeast Atlantic); ROMPE: Regional organization for the Protection of the Marine Environment (ROMPE sea area); UNEP-MAP: UN Environment Mediterranean Action Plan (Mediterranean Sea)).

Regional Seas Programme/ Organisation	Indicator/assessment criteria
OSPAR	Harmonised assessment criteria: Category I: Degree of nutrient enrichment 1) Riverine inputs and direct discharges [nitrogen, phosphorous] 2) Nutrient concentrations [DIN and/or DIP] 3) N/P ratio

[25] Continuous Plankton Recorder: https://www.sahfos.ac.uk/services/the-continuous-plankton-recorder/

[26] https://www.unenvironment.org/news-and-stories/story/neat-satellite-based-technique-keep-eye-growing-eutrophication-threat-oceans

[27] Regional Seas Programmes that use dissolved oxygen levels as indicator for eutrophication: OSPAR (Northeast Atlantic), HELCOM (Baltic Sea), NOWPAP and CPPS (Southeast Pacific)

	Category II: Direct effects of nutrient enrichment (during growing season) 1) Chlorophyll-a concentration (area specific) 2) Phytoplankton indicator species (area specific) 3) Macrophytes including macroalgae (area specific) Category III: Indirect effects of nutrient enrichment (during growing season) 1) Oxygen deficiency 2) Zoobenthos and fish 3) Organic carbon/organic matter (area specific) Category IV: Other possible effects of nutrient enrichment (during growing season) 1) Algal toxins
HELCOM	Indicators for eutrophication: 1) Water clarity 2) Nitrogen/DIN 3) Total nitrogen 4) Chlorophyll-a concentration 5) Oxygen debt 6) Inputs of nutrients to the sub basins 7) Phosphorus/DIP 8) Total phosphorus 9) Cyanobacterial bloom index
UNEP-MAP	Common Indicators under Ecological Objective 5 Eutrophication: 1) Common Indicator 13 Concentration of key nutrients in water column 2) Common Indicator 14 Chlorophyll-a concentration in water column
Nairobi Convention	*Chlorophyll-a concentration as indicator of phytoplankton primary productivity*
NOWPAP	Common Procedures for Eutrophication Assessment (minimum required parameters): 1) Trend in chemical oxygen demand (DOD) or Total Organic Carbon (TOC) 2) Frequencies of red tide and hypoxia events 3) Level and trend in satellite derived Chlorophyll-a
ROMPE	*Chlorophyll-a concentration as indicator of phytoplankton biomass*
CPPS	Indicator 7 Water Quality Index, parameters include: 1) Phosphate 2) Nitrate 3) Dissolved oxygen 4) Chlorophyll-a
European Environment Agency	Indicator 23 Chlorophyll in transition, coastal and marine waters
EU MSFD (Marine Directive)	Descriptor 5 (Eutrophication) indicators: Criteria 5.1 Nutrients levels: ● 5.1.1 Nutrients concentration in the water column. ● 5.1.2 Nutrient ratios (silica, nitrogen and phosphorus), where appropriate. Criteria 5.2 Impacts of litter on marine life: ● 5.2.1 Chlorophyll concentration in the water column. ● 5.2.2 Water transparency related to increase in suspended algae, where relevant. ● 5.2.3 Abundance of opportunistic macroalgae. ● 5.2.4 Species shift in floristic composition such as diatom to flagellate ratio, benthic to pelagic shifts, as well as bloom events of nuisance/toxic algal blooms (e.g. cyanobacteria) caused by human activities. Criteria 5.3 Indirect effects of nutrient enrichment: ● 5.3.1 Abundance of perennial seaweeds and seagrasses (e.g. fucoids, eelgrass and Neptune grass) adversely impacted by decrease in water transparency.

	• 5.3.2 Dissolved oxygen, i.e. changes due to increased organic matter decomposition and size of the area concerned.
EU WFD	*Chlorophyll-a as phytoplankton parameter indicative of biomass*
UN Strategic Plan for Biodiversity (2010-2020)	Indicators for 'Trends in nutrient levels' (Aichi Target 8.4) include: 1) Trends in Nitrogen deposition 2) Trends in Loss of reactive nitrogen to the environment 3) Trends in Global surplus of nitrogen 4) Proportion of bodies of water with good ambient water quality 5) Proportion of wastewater safely treated
GEF-TWAP	*Chlorophyll-a concentrations and trends as indicator for productivity*
NOAA	Chlorophyll-a as indicator of primary eutrophication symptoms

SDGIndicator 14.1.1.b

A review of existing indicators and methodologies used by Regional Seas Programmes and other key intergovernmental, international or regional bodies shows that marine plastic debris is currently monitored in four areas of the marine environment.

1) Plastic debris washed/deposited on beaches or shorelines (beach litter): Beach litter monitoring is done through beach surveys following standardised monitoring protocols or guidelines and can be completed in rapid assessment surveys or routine monitoring. Rapid assessment surveys are applied to understand the effects of a major natural disaster, to establish a baseline for routine monitoring and to locate accumulation 'hot-spots' for mitigation. The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) completed *Guidelines for the Monitoring and Assessment of Plastic Litter in the Ocean* that detail various methods for beach surveys including by type of litter (macro and mega litter, buried macro-plastics, meso-litter and micro-litter). UN Environment and IOC-UNESCO have jointly produced *Guidelines on Survey and Monitoring of Marine Litter* (Cheschire et al. 2009), which include operational guidelines for beach litter surveys and are used as guidance by several Regional Seas Programmes. The European Commission's Joint Research Centre also provides beach litter monitoring protocols in its *Guidance on Monitoring of Marine Litter in European Seas* (European Commission JRC 2013). Further available guidance documents and toolboxes for beach litter monitoring are listed in Table 5. Beach litter surveys often take place in connection with beach clean-ups involving the local public. For example, the Ocean Conservancy's International Coastal Clean-up (ICC) initiative organises beach clean-ups around the world using standardised ICC data cards[28]. The ICC data cards are used as protocols to collect beach litter data in the four NOWPAP (Northwest Pacific) countries as well as some of the Caribbean Member States of the Cartagena Convention. Another avenue for collecting beach litter data is through citizen science programmes, such as the Marine LitterWatch application and data viewer of the European Environment Agency, or NOAA's Marine Debris Monitoring and Assessment Citizen Science Project[29].

Table 13: Available guidance material for beach litter monitoring produced by Regional Seas Programmes and other intergovernmental, international, regional bodies or national bodies. (CCAMLR: Convention for the Conservation of Antarctic Marine Living Resources (Antarctic Sea); JRC: Joint Research Centre (European Commission); NOAA: National Oceanic and Atmospheric Administration; NOWPAP: Northwest Pacific Action Plan (Northwest Pacific); OSPAR: Oslo-Paris Convention (Northeast Atlantic); IOC-UNESCO: Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization).

Regional Seas Programme/	Monitoring protocols and guidelines	Available at:

[28] Ocean Conservancy International Coastal Clean-up data card: http://act.oceanconservancy.org/ site/DocServer/ICC_Eng_DataCardFINAL.pdf?docID=4221

[29] NOAA Marine Debris Monitoring and Assessment Citizen Science Project: https://marinedebris.noaa.gov/research/marine-debris-monitoring-and-assessment-project

Organisation		
CCAMLR (Antarctic Sea)	The *Arctic Marine Strategic Plan 2015-2025* provides standard data forms and instructions for beach survey data collection (Arctic Council 2015)	https://oaarchive.arctic-council.org/handle/11374/413
European Commission Joint Research Centre (JRC)	*Guidance on Monitoring of Marine Litter in Europeans Seas* (European Commission JRC 2013)	https://ec.europa.eu/jrc/sites/jrcsh/files/lb-na-26113-en-n.pdf
NOAA	*NOAA Marine Debris Shoreline Survey Field Guide* (Opfer et al. 2012), and a monitoring toolbox with protocol documents and field data sheets	https://marinedebris.noaa.gov/sites/default/files/ShorelineFieldGuide2012.pdf
NOWPAP (Northwest Pacific)	*Guidelines for Monitoring Marine Litter on the Beaches and Shorelines of the Northwest Pacific Region* (NOWPAP CEARAC 2007)	http://www.cearac-project.org/RAP_MALI/monitoring%20guidelines.pdf
OSPAR (Northeast Atlantic)	*Guidelines for monitoring marine litter on the beaches in the OSPAR Maritime Area* (OSPAR 2010)	https://www.ospar.org/ospar-data/10-02e_beachlitter%20guideline_english%20only.pdf
UN Environment and IOC-UNESCO	*UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter* (Cheshire et al. 2009)	http://staging.unep.org/gpa/Documents/Publications/MarineLitterSurveyandMonitoringGuidelines.pdf
UN Environment	*Marine plastic debris and microplastics – Global lessons and research to inspire action and guide policy change* (UNEP 2016b)	https://wedocs.unep.org/rest/bitstreams/11700/retrieve
GESAMP	*Guidelines for the Monitoring and Assessment of Plastic Litter in the Ocean*	https://environmentlive.unep.org/media/docs/marine_plastics/une_science_dvision_gesamp_reports.pdf

2) Plastic debris in the water column: Marine litter in the water column is monitored based on the identification goals, the type of litter targeted and the conditions of the sampling location. The GESAMP guidelines explain various methods based on the composition, size and location of the marine litter including considerations for the goals of the monitoring (GESAMP 2019). Methods include visual and/or photographic observations from ships or airplanes, bulk water samples, surface water and water column trawls and remote sensing. Visual observations and trawls usually make use of monitoring activities for other ecological variables (e.g. fish populations). HELCOM (Helsinki Commission, Baltic Sea), UN Environment Mediterranean Action Plan (UNEP-MAP; Mediterranean Sea) and the South Asian Seas Action Plan have indicators and methodologies in place for monitoring marine litter in the water column. Methodologies for floating litter are also included in the guidelines from UN Environment/IOC-UNESCO and the European Commission Joint Research Centre.

3) Plastic debris on the seafloor/seabed: Methodologies used to monitor litter on the seafloor include that used by Europe’s International Bottom Trawl Surveys (IBTS) and other fish bottom trawls, as well as visual observations by divers and snorkelers (shallow waters), submersibles, remotely operated vehicles and camera tows (shallow and deeper waters). Three European Regional Seas Programmes[30] currently have indicators and monitoring methodologies in place for seafloor litter. Guidance on seafloor litter monitoring methodologies is also included in the guidelines from

[30] Regional Seas Programmes that are monitoring seafloor litter: OSPAR (Northeast Atlantic), HELCOM (Baltic Sea) and UNEP-MAP (Mediterranean Sea)

GESAMP, UN Environment/IOC-UNESCO and the European Commission Joint Research Centre (GESAMP 2019).

4) Plastic ingested by biota (e.g. sea birds): The GESAMP guidelines outline methods for monitoring plastic ingested by biota such as taking samples from dead organisms and sampling fom live animals via regurgitated pellets, scat, nesting material or entangled litter. The guidelines also describe options for monitoring various biota groups including: phytoplankton, zooplankton, shellfish, other invertebrates and marine mammals, birds and fish (GESAMP 2019). OSPAR (Northeast Atlantic), UNEP-MAP (Mediterranean Sea) and the EU Marine Directive also include provisions for monitoring marine plastic litter through analysis of plastic ingested by stranded marine biota (mainly seabirds, turtles and fish). This approach is limited by the natural range of the indicator species and consistency of availability of stranded animals, as well as requiring the capacity to collect and analyse the animals. In addition to ingestion by marine biota, the EU Marine Directive, as well as the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR, Antarctic Sea), also consider marine plastic found in nests and seabird colonies and marine mammal entanglement.

The marine plastic debris indicators related to these methodologies are summarised in Table 6. While the monitoring methods described above focus largely on macroplastics, some of the existing indicators also refer to microplastics. HELCOM (Baltic Sea) and the European Commission Joint Research Centre provide guidance on monitoring methodologies for microplastic particles: 1) manta trawls/plankton nets in the water column, and 2) sieving of sediment/sand samples from beaches or the seafloor. Further guidance on sampling and analysing of microplastics is provided by GESAMP, Working Group 40[31], which in 2016 produced a report on *Sources, Fate and Effects of Microplastics in the Marine Environment* (GESAMP 2016) to inform the Second UN Environment Assembly.

Table 14: Summary of marine plastic debris indicators currently used by Regional Seas Programmes and other key intergovernmental, international or regional bodies. (EU MSFD: European Union Marine Strategy Framework Directive; HELCOM: Helsinki Commission (Baltic Sea); NOWPAP: Northwest Pacific Action Plan (Northwest Pacific); OSPAR: Oslo-Paris Convention (Northeast Atlantic); UNEP-MAP: UN Environment Mediterranean Action Plan (Mediterranean Sea)).

Regional Seas Programme/ Organisation	Indicator/assessment criteria
OSPAR	Three marine litter indicators: 1) Beach litter 2) Plastic particles in Fulmars' stomachs 3) Seabed litter Indicators under development: ● Indicators using other biota ● Indicators for microplastics
HELCOM	HELCOM indicators for marine litter: 1) Indicator on beach litter 2) Status of implementation of the HELCOM Regional Action Plan on Marine Litter Indicators under development: ● Litter on the seafloor ● Micro litter in the water column
UNEP-MAP	Common Indicators under Ecological Objective 10 Marine Litter: ● Common Indicator 22: Trends in the amount of litter washed ashore and/or deposited on coastlines. ● Common Indicator 23: Trends in the amount of litter in the water column including microplastics and on the seafloor.

[31] GESAMP Working Group 40 is led by IOC-UNESCO and UN Environment.

	• Candidate Indicator 24: Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds, and marine turtles.
NOWPAP	Indicator for marine litter (Ecological Quality Objective 5) to be developed
UN Environment	Beach litter as an indicator for floating plastic debris density
EU MSFD (Marine Directive)	Descriptor 10 (Marine litter) indicators: Criteria 10.1 Characteristics of litter in the marine and coastal environment: • 10.1.1 Trends in the amount of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source. • 10.1.2 Trends in the amount of litter in the water column (including floating at the surface) and deposited on the seafloor, including analysis of its composition, spatial distribution and, where possible, source • 10.1.3 Trends in the amount, distribution and, where possible, composition of microparticles (in particular microplastics). Criteria 10.2 Impacts of litter on marine life: • 10.2.1 Trends in the amount and composition of litter ingested by marine animals (e.g. stomach analysis).
UN Strategic Plan for Biodiversity (2010-2020)	[…] Floating Plastic Debris Density (Aichi Target 8)
Ocean Conservancy	Ocean Trash Index: presence of litter items in five 'activity categories': 1) Shoreline and recreational 2) Ocean and waterway 3) Smoking related 4) Dumping 5) Medical or personal hygiene

SDG Indicator 14.2.1

Indicator 14.2.1 refers to the management of exclusive economic zones using ecosystem-based approaches.

1) Ecological indicators for the quality of marine ecosystems: OSPAR (Northeast Atlantic) and UNEP-MAP (Mediterranean Sea) are using ecological indicators to monitor and assess the implementation of the ecosystem approach. The OSPAR indicators are in line with the descriptors of 'good environmental status' which are used to assess ecosystem-based marine management under the EU Marine Directive. The ecological indicator approach taken by OSPAR, UNEP-MAP and the European Union requires the measurement and monitoring of a large number of biochemical parameters for an integrated assessment of the state of marine ecosystems and biodiversity. This implies high levels of resources and technical capacity for ecological monitoring. Moreover, as evidenced by experience in the OSPAR region (Northeast Atlantic), the applicability and relevance of ecological indicators and associated methodologies may vary between different locations within one region.

2) Indicators for integrated management and planning strategies for socio-ecological systems: Other ecosystem approach indicators are based on the implementation status of marine area-based, integrated planning and management approaches, such as Marine/Maritime Spatial Planning (MSP) and/or Integrated Coastal Zone Management (ICZM). HELCOM (Baltic Sea) has adopted the ecosystem approach as one of ten Baltic Sea Broad-Scale Maritime Spatial Planning Principles (HELCOM-VASAB 2010) and has identified *drawing up and application of maritime spatial plans throughout the Baltic Sea by 2020* as one of the HELCOM regional targets that will contribute towards the delivery of SDG 14.2 (HELCOM 2017). The HELCOM indicator for the delivery of this target is '*number of countries having maritime spatial plans coherent across borders and applying the*

ecosystem approach'. Similarly, the Strategic Action Plan under the Nairobi Convention (Western Indian Ocean Region) includes '*Integrated Coastal Zone Management policies, plans and/or legislation in place in all countries'* as one of the indicators for protection, restoration and sustainable management of critical coastal habitats (Nairobi Convention Secretariat 2009). The Nairobi Convention indicator is translated into a target with a baseline and short, medium and long-term outcomes against which progress can be measured. In comparison to ecological indicators, management based indicators incur low implementation costs, as they do not require technical capacity or resources for ecological monitoring, and can easily be applied at regional and national levels across the world.

The ecosystem approach indicators and assessment criteria described here are summarised in Table 8. Referring back to SDG 14, Target 14.2 calls for sustainable management and protection of marine and coastal ecosystems. Integrated planning and management approaches, such as Marine/Maritime Spatial Planning or Integrated Coastal Zone Management, have been identified as key tools for sustainable, ecosystem-based management (Ehler and Douvere 2009). Consequently, the implementation of these approaches can be considered as a valid indicator for ecosystem-based management.

Table 15: Summary of ecosystem approach indicators and assessment criteria currently used by Regional Seas Programmes and other key intergovernmental, international or regional bodies. (EU MSFD: European Union Marine Strategy Framework Directive; HELCOM: Helsinki Commission (Baltic Sea); ICZM: Integrated Coastal Zone Management; MSP: Marine Spatial Planning; NOWPAP: Northwest Pacific Action Plan (Northwest Pacific); OSPAR: Oslo-Paris Convention (Northeast Atlantic); UNEP-MAP: UN Environment Mediterranean Action Plan (Mediterranean Sea)).

Regional Seas Programme/ Organisation	Indicator/assessment criteria
OSPAR	Ecological indicators that are in line with MSDF Descriptors of good environmental status
HELCOM	HELCOM indicator for maritime spatial planning: Number of countries having maritime spatial plans coherent across boarders and applying the ecosystem approach
UNEP-MAP	Common Indicators (ecological indicators)
NOWPAP	Mid-Term Strategy 2018-2023 Objective: NOWPAP countries increasingly apply ecosystem-based approach to planning and management as a basis to achieve healthy and productive coastal and marine ecosystems. Outcomes/ Expected Accomplishments for this priority area: ● NOWPAP member states are developing and applying ecosystem-based management policies, tools and practices to support sustainable development of coastal zones and the marine environment; ● Planning and decision-making processes for ICZM and MSP by NOWPAP member states recognize inter-connectedness between the land and the sea and promote cross-sectoral cooperation; ● 1.3. Planning mechanisms, including integrated water resources management, ICZM and MSP in NOWPAP member states contribute to reduced pressures on the coastal and marine environment.
EU MSFD (Marine Directive)	Descriptors of good environmental standard (ecological indicators)

SDG Indicator 14.5.1

A review of existing indicators and methodologies for monitoring the coverage of Marine Protected Areas (MPAs) used by Regional Seas Programmes and other key intergovernmental, international or regional bodies shows that six Regional Seas Programmes currently have indicators, assessment criteria or reporting in place for MPA coverage, as does the Global Environment Facility Transboundary Waters Assessment Programme (GEF-TWAP). Table 10 summarises the key criteria of the different approaches. The two most frequently assessed and reported criteria are 'number of

MPAs' and 'total (surface) area covered by MPAs (coverage in km^2)'. Some Regional Seas Programmes also calculate 'the percentage of total marine area covered by MPAs (percentage %)' or 'changes in coverage (in km^2 or percentage %)'.

Table 16: Key criteria of existing indicators, assessment criteria or reporting requirements related to Marine Protected Areas (MPAs) that are currently used by Regional Seas Programmes and by the Global Environment Facility Transboundary Waters Assessment Programme (GEF-TWAP). (OSPAR: Oslo-Paris Convention (Northeast Atlantic); HELCOM: Helsinki Commission (Baltic Sea); Bucharest Convention (Black Sea); NOWPAP: Northwest Pacific Action Plan (Northwest Pacific); CPPS: Commission for the South Pacific (Southeast Pacific); Arctic Council (Arctic Sea).

	OSPAR	HELCOM	Bucharest Convention	NOWPAP	CPPS	Arctic Council	GEF-TWAP
Number of MPAs	✔	✔	✔	✔	✔	✔	✔
Total area covered by MPAs (km^2)	✔	X	✔	✔	X	✔	✔
Percentage of total marine area covered by MPAs (%)	✔	✔	X	✔	X	✔	X
Trends/changes in MPA coverage (km^2; %)	X	X	✔	X	✔	✔	✔
Distribution across IUCN management categories	X	X	X	X	✔	✔	X
Management in place	✔	✔	X	X	X	X	X
Percentage of marine areas covered by MPAs in relation to Aichi Target 11[32]	X	X	X	✔	X	X	X
Ecological coherence	✔	X	X	X	X	X	X
Geographic extent (in terms of global distribution of MPAs)	X	X	X	X	X	X	✔

Existing regional approaches to calculating MPA coverage require clear definitions of 1) what is considered as an MPA, and 2) the total (surface) area considered by the indicator. These are prerequisite for being able to calculate MPA coverage, and the proportion (percentage) of total marine area covered. Some Regional Seas Programmes, for example OSPAR (Northeast Atlantic) and HELCOM (Baltic Sea) have their own definitions of what they consider as an MPA. Others use the protected area definition[33] and management categories[34] of the International Union for Conservation of Nature (IUCN). CPPS (Southeast Pacific) and the Arctic Council (Arctic Sea), for example, report on the distribution of MPAs across IUCN management categories.

[32] UN Stratgic Plan for Biodiversity (2010-2020) – Aichi Target 11 *By 2020, at least 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape.* For more information about the target: https://www.cbd.int/sp/targets/rationale/target-11/

[33] IUCN definition of protected area: "*a clearly defined 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*" (Dudley, N. (ed.) 2008. Guidelines for Applying Protected Area Management Categories. IUCN: Gland, Switzerland. p.8-9.)

[34] IUCN protected area management categories: Ia Strict Nature Reserve, Ib Wilderness Area, II National Park, III Natural Monument or Feature, IV Habitat/Species Management Area, V Protected Landscape/Seascape, VI Protected area with sustainable use of natural resources. Online: https://www.iucn.org/theme/protected-areas/about/protected-area-categories

MPA coverage indicators and assessment criteria currently used by Regional Seas Programmes and other key intergovernmental, international or regional bodies are summarised in Table 11.

Table 17: Summary of marine protected area (MPA) coverage indicators and assessment criteria currently used by Regional Seas Programmes and other key intergovernmental, international or regional bodies. (Arctic Council (Arctic Sea); Bucharest Convention (Black Sea); CPPS: Permanent Commission for the South Pacific (Southeast Pacific); GEF-TWAP: Global Environment Facility Transboundary Waters Assessment Programme; HELCOM: Helsinki Commission (Baltic Sea); IUCN: International Union for Conservation of Nature; NOWPAP: Northwest Pacific Action Plan (Northwest Pacific); OSPAR: Oslo-Paris Convention (Northeast Atlantic).

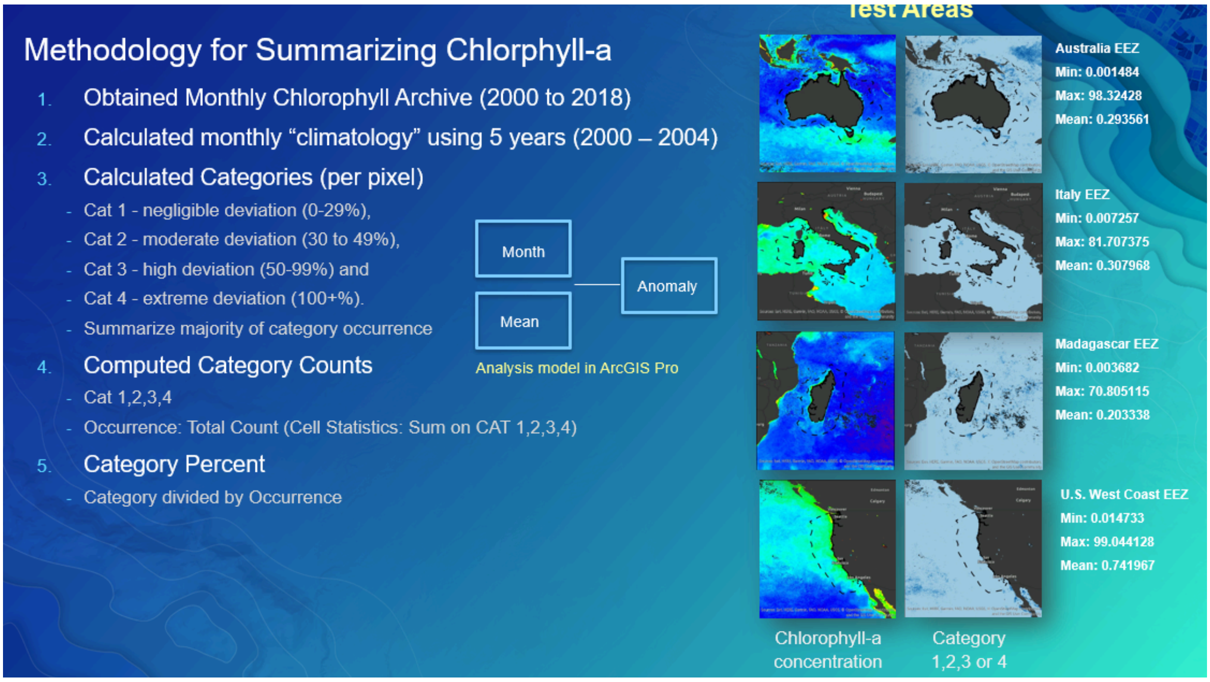
Regional Seas Programme/ Organisation	Indicator/assessment criteria
OSPAR	Criteria for assessing the ecological coherence of OSPAR MPAs: 1) Geographically well distributed (connectivity), 2) Cover at least 10% in area of all biogeographic provinces (representativeness), 3) Represent all EUNIS Level 3 habitat classes and OSPAR threatened and/or declining species and habitats (features and resilience).
HELCOM	HELCOM indicators: 1) Coverage of protected areas in relation to marine areas, including in individual sub-basins of the Baltic Sea and exclusive economic zone 2) Percentage of HELCOM MPAs having management plans or measures in place
Bucharest Convention	Indicator for Ecological Quality Objective 2b (Conserve coastal and marine habitats and landscapes): Number and total area of marine and coastal protected areas increased
NOWPAP	Reporting on: ● Number of MPAs ● Area of MPAs in km^2 ● Total regional coverage of MPAs in % of exclusive economic zone
CPPS	Indicator 1: Marine and Coastal Protected Areas, reported as: 1) Number of marine and coastal protected areas per IUCN category 2) Total surface of marine and coastal protected areas per IUCN category (km^2) 3) Marine and coastal surface area by country 4) Marine and coastal protected areas in the Southeast Pacific 5) Increase in surface area of marine and coastal protected areas by country 2004–2015 (km^2) 6) Percentage of marine and coastal protected areas in relation to Aichi Target 11
Arctic Council	Reporting on: 1) Number and area covered (% and km^2 of Arctic marine area), based on clear definitions of Arctic marine area boundaries (from the Conservation of Arctic Flora and Fauna (CAFF) working group) and of MPAs; 2) Trends in marine protected area coverage within the CAFF boundary 1900-2016 (in % of area covered) 3) Distribution of MPAs across each of the six IUCN Management Categories (in % of area covered) Also reporting on number and area covered (% and km^2) of other area-based measures of importance for Arctic marine biodiversity, including % within MPAs: 1) Areas of heightened ecological and cultural significance 2) Ecologically or Biologically Significant marine Areas (EBSAs) 3) Particularly Sensitive Sea Areas (PSSAs)
GEF-TWAP	Indicator: Change in protected area coverage within Large Marine Ecosystems (LMEs) 1) Number 2) Total area 3) Geographic extent 4) Index of percentage change (1982-2014) in total area covered by MPAs per LME 5) Cumulative area of MPAs in all LMEs

Appendix 3: Country case studies and examples

As mentioned the approaches in this manual have been extensively testing in various Regional Seas Programmes. In addition the the experiences on specific indicators, the overall approach in this manual was pilot testing in Colombia and Fiji. The country case studies in this section focuses on Fiji and Colombia while also brining in some additional information and experiences.

SDG Indicator 14.1.1a

Deviations in chlorphyll-a for different thresholds was analysed in order to choose a threshold for anomalies. This approach was tested in Australia, Italy, Madagascar and the United States (including the West Coast and the Gulf of Mexico). Based on this analysis, negligible and moderate deviations as defined below are relatively common whereas a cut of of 50% represents an anamoly.



Text Box 1 summarises findings from the country missions to Fiji and Colombia on national monitoring programmes for eutrophication, and national capacity for using satellite remote sensing to collect Chlorophyll-a data for tracking progress against SDG Target 14.1.

Text Box 1: Insights from the country missions on eutrophication monitoring using Chlorophyll-a

Fiji: Focus on regional scale and institutions

Fiji does not currently have a national monitoring programme for eutrophication. Using satellite remote sensing to provide Chlorophyll-a data for monitoring eutrophication was seen as a possible option by the government representatives consulted during the country mission. However, an issue of scale was noted: would satellite image resolutions be sufficiently fine for the monitoring of eutrophication around small islands? For Fiji and other small, multi-island states in the Pacific, satellite remote sensing of Chlorophyll-a might be more appropriate to monitor eutrophication at a regional scale than at country/island level.

In this context, it is worth noting that, for Fiji and other Pacific island states, regional institutions play an important role in data collection, indicator assessment, reporting and policy implementation. Key regional bodies are the Secretariat of the Pacific Regional Environmental Programme (SPREP; i.e. the Secretariat of the Pacific Regional Seas Programme), and the Pacific

Community, a regional intergovernmental organisation that supports the island states and has responsibility for data. This regional support is key as Pacific island states often lack the resources and capacity for large scale data collection and monitoring.

Of note is the fact that SDG Indicators 14.1.1a and 14.1.1b are not included in the 109 SDG indicators that the Pacific SDGs Taskforce and the Pacific Statistics Steering Committee has decided to take forward in the region. This could present a major issue for countries in the region, such as Fiji, given the major role that regional bodies play there in monitoring and reporting.

Colombia: Strong in-country capacity for national monitoring

Colombia is not currently monitoring eutrophication at national level. It is understood that data collected on dissolved oxygen, nutrients, Chlorophyll-a and microplastics feed into the national indicator on marine and coastal water quality.

For Chlorophyll-a, Colombia is using satellite observations from the NASA MODIS-Aqua mission, with daily temporal resolution, and spatial resolution of 1 km, as well as monthly composite images at 4 km. The Chlorophyll-a satellite data are calibrated with samples taken *in situ* and measured in the laboratory by spectrophotometry, using the Lorenzen method.

Colombia has in-country capacity for using satellite remote sensing to monitor Chlorophyll-a concentrations at national level. The country is currently planning a pilot study at sub-national level and developing a roadmap for monitoring Chlorophyll-a.

Text box 2 illustrates two examples of South African cities evaluating marine pollution and seeking to understand the impacts on the marine environment. These examples include pollutants that could contribute to chlorophyll spikes and portray a need for collecting data to inform indicator 14.1.1a so that localities have the resources to respond to pollution events.

Text Box 2: Challenges in Monitoring Marine Outfall Sites in South Africa

Durban: Environmental Surveys in Outfall Regions

Researchers in Durban have developed a monitoring programme to study the effects of wastewater discharge into the marine environment (Newman 2019). Many coastal cities discharge their wastewater to the sea through deep water outfalls, but due to the changing composition of modern wastewater (as a result of shifts in household and industry waste), there is limited knowledge about the impacts of these outfalls on the marine environment.

The monitoring programme in Durban is managed by The Council of Scientific and Industrial Research (CSIR) and it has lasted over 40 years, making it one of the longest continuous monitoring programmes in South Africa (Newman 2019). This monitoring programme is an example of how sub-national data collection is important. Information from this monitoring programme could build toward data collection for indicator 14.1.1a.

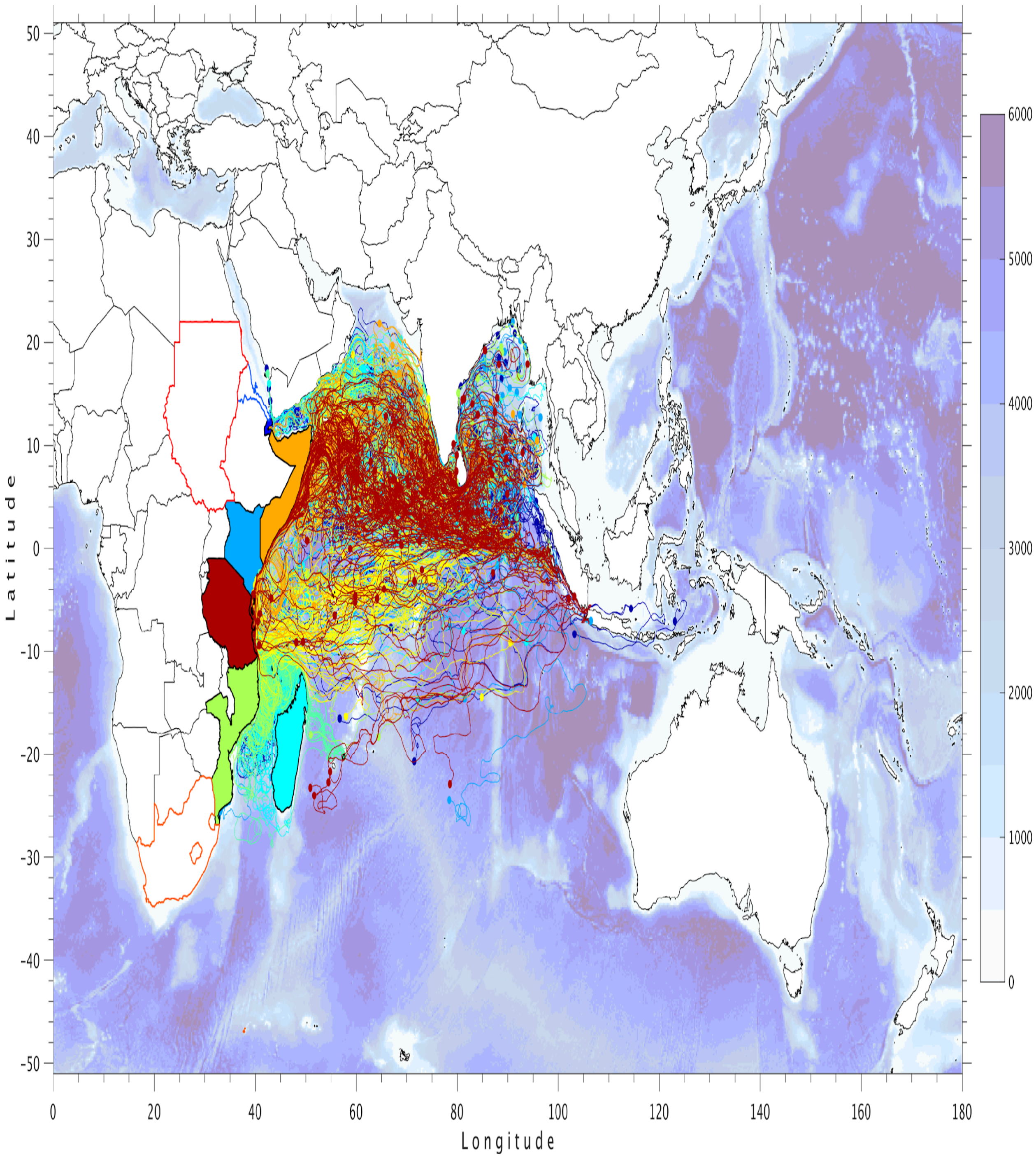
Cape Town: Responding to New Pollutants in Sewage Outfall Sites

Cape Town needs to adapt wastewater treatment technologies in response to recent evidence that household pollutants are spiking in the marine environment (Petrik *et al* 2017). Following proposals to produce drinking water by desalination, this study examined the marine environment near sewage outfall sites to assess evidence of factors that could only have been sourced from human sewage. The findings confirm that seawater and beach water samples occasionally present health risks. Despite these findings, city officials failed to respond, with recent articles stating that the city did not publish water quality tests for two years and that chemicals from sewage outfall sites are accumulating on Cape Town beaches (Kretzmann 2019a; Kretzmann 2019b). This lack of data is a critical issue to approaching solutions; in response, researchers are calling for investigation into new treatment technologies.

Ongoing monitoring and data collection toward SDG 14.1.1a as recommended throughout this manual could support this issue with a knowledge base to inform past pollutants. This could assist in developing new technologies by providing proof that the new technologies are required to respond to the pollutants. Furthermore, the data nationally could build capacity and therefore help local governments with guidance to on how to react to marine pollution problems.

SDG Indicator 14.1.1b

For modelling of plastic flow, the below is the results of a simulation of particle accumulation in Kenya based Simulated particles that flow within 15-km of the Kenyan coastline from the eastern African countries (top panel) and from the Asian countries (bottom panel) during the 2-year simulation. Color-shaded countries have particles that reached Kenya coast. For legibility purpose, 1 out of 5 particles are shown for Comoros (618), Kenya (552), and Somalia (875); 1 out of 10 particles are shown for the United republic of Tanzania (1151) and for Indonesia (1073).



UN Environment in collaboration with CSIRO pilot tested the methodology on collecting data. CSIRO has led pilots (or is in the process of finalizing a pilot) int the following countries: Bangladesh, China, Republic of Korea, Vietnam, Chile, Ghana, Kenya, Mauritius, Nigeria, Brazil, India, Indonesia, Pakistan, Peru, Philippines, South Africa, Sri Lanka, Thailand and the United States. More information on this piloting can be found at https://uneplive.unep.org/egm, on the CSRIO website or in the GESAMP methodologies.

Text Box 3 summarises findings, from the country missions to Fiji and Colombia, on national monitoring programmes for marine plastics, and on using beach litter surveys for tracking progress against SDG Target 14.1.

Text Box 3: Insights from the country missions on marine plastics monitoring using beach litter

Fiji: Potential to capitalise on existing beach clean-ups

Fiji does not currently have a national monitoring programme for marine plastics. Beach clean-ups do take place in the country; however, these events tend to be organised locally and data are not generally collected. *A future national monitoring programme could build on these local beach clean-ups by integrating them into the step-by-step methodology for the beach litter SDG indicator.*

Some national and regional data are also available for microplastic concentrations in surface waters, sediments and organisms. These microplastics data are gathered using NOAA methodologies for marine samples.

As already noted for eutrophication monitoring (see Text Box 1), regional bodies play a key role in Fiji and other Pacific island states with regard to data collection, indicator assessment, reporting and policy implementation. As noted earlier, SDG Indicators 14.1.1a and 14.1.1b are not included in the 109 SDG indicators that the Pacific SDGs Taskforce and the Pacific Statistics Steering Committee decided to take forward in the region.

Colombia: Focus on microplastics

Colombia is not currently monitoring marine plastics at the national level. However, microplastics data are being collected in six pilot stations from *in situ* sediment, water and fish samples. These data are understood to feed into the national marine and coastal water quality indicator.

SDG Indicator 14.2.1

Text Box 4 summarises findings from the country missions to Fiji and Colombia on national efforts towards monitoring the implementation of ecosystem-based approaches and using ICZM plans for tracking progress against SDG Target 14.2.

Text box 4: Insights from the country missions on monitoring the implementation of ecosystem-based approach using ICZM

Fiji: Awaiting a national marine spatial planning framework

Fiji is committed to implementing marine spatial planning across its entire national waters, including the Exclusive Economic Zone. One way for Fiji to realise this commitment might be to adopt a similar approach to that taken in Colombia, which has developed its own tailored ICZM approach, based on UNESCO's *Methodological Guide to Integrated Coastal Zone Management* (Henocque and Denis 2001). This way forward was noted by participants consulted during the in country mission.However, a national framework for marine spatial planning or ICZM in Fiji is not yet in place. Consequently, there is currently no clear plan for the implementation of SDG Indicator 14.2.1 or its ICZM indicator. A possible option noted during the country mission would be for Fiji to assess the implementation of ecosystem-based management in its waters through Locally Managed Marine Areas, which are taking an ecosystem based approach.

Colombia: A national indicator on ICZM implementation

Colombia is already implementing its own national indicator for SDG Indicator 14.2.1. The national indicator '*progress in the implementation of planning instruments for marine and coastal zones*' provides information on the existence, and state of implementation progress of ICZM in geographically defined coastal zone areas, which are referred to as *Coastal and Oceanic Environmental Units* (UAC in Spanish). The indicator measures the number of UACs that are making progress towards the implementation of ICZM, and specifies what stage of the ICZM implementation process each UAC is at. It is calculated using the following formula:

$$\frac{\text{\# UAC with progress in N stage from the ICZM methodology x 100}}{\text{\# Total of UAC in coastal zones}}$$

Where 'N' refers to one the following stages:

1. Preparation
2. Characterization
3. Diagnostic
4. Foresight and environmental zoning
5. Guidelines
6. Formulation
7. Adoption
8. Implementation/Execution
9. Monitoring and evaluation

The indicator results are spatially presented as a map, onto which the UACs are colour-coded depending on their ICZM implementation stages (see Figure 3). The Colombian indicator currently focuses on coastal areas but has the potential to be adapted to include the country's Exclusive Economic Zone.

Colombia's national indicator approach is very similar to the step-by-step methodology for the 'ICZM protocol' indicator presented in the *Global Manual*. The Colombian formula to calculate ICZM implementation progress could provide an alternative option to the step-by-step methodology for countries to implement the indicator for SDG Target 14.2.

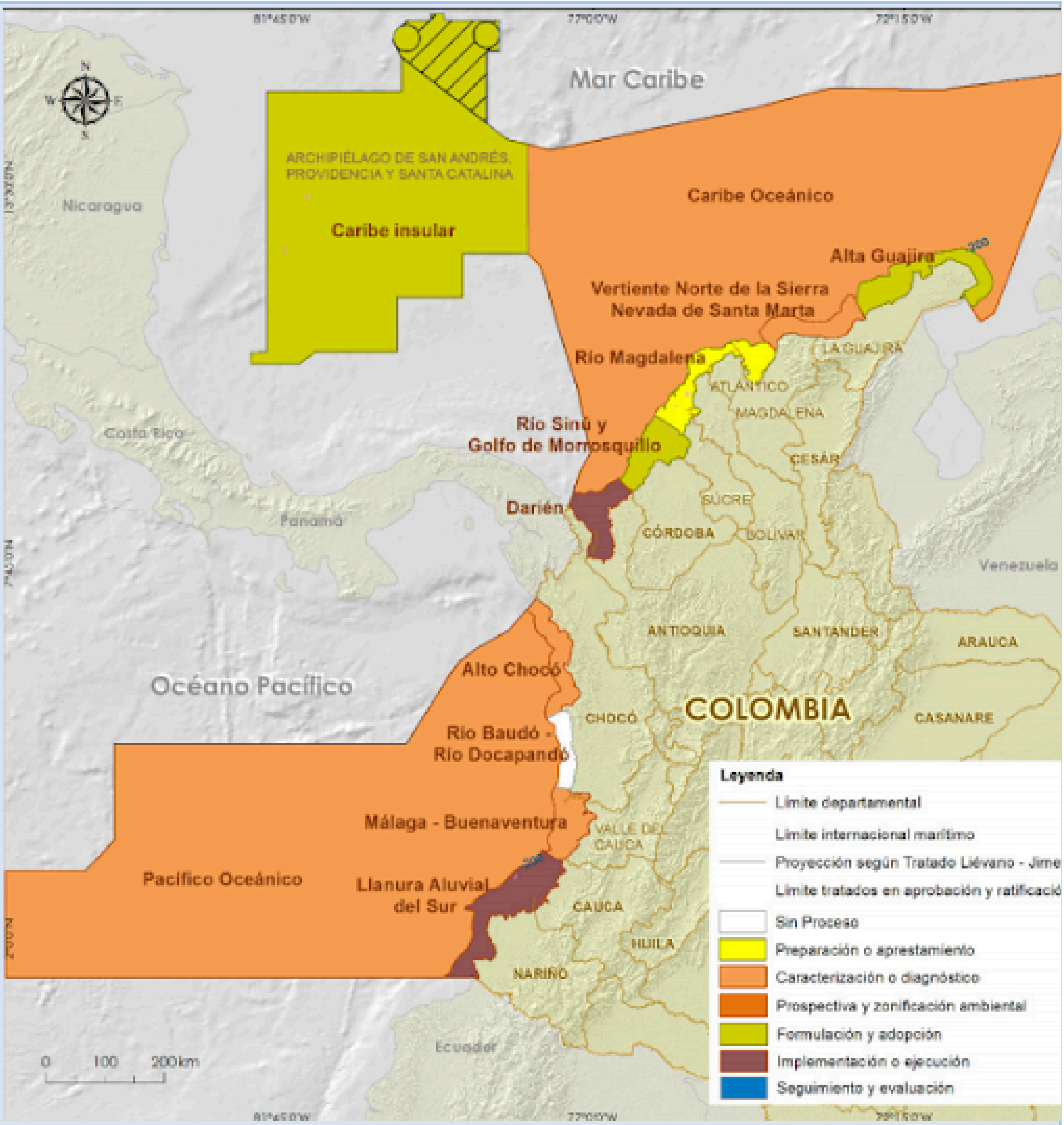


Figure 3: Spatial distribution of progress in the implementation of Integrated Coastal Zone Management (ICZM) for the period of 1999-2014 in Colombia, based on the national indicator 'progress in the implementation of planning instruments for marine and coastal zones'. The colours refer to the different implementation stages: White: no progress; Yellow: preparation; Orange: characterization; Red: foresight and environmental zoning; Green: formulation and adoption; Brown: implementation/execution; Blue: monitoring and evaluation. (Source: INVEMAR 2015)

Text box 5 provides an overview of examples where ICZM is currently implemented in different Regional Seas Programmes. All examples were adapted from the informational document on the Regional Seas Indicator 22: National Integrated Coastal Zone Management (ICZM) guidelines and enabling legislation are adopted (reference).

Text Box 5: Examples of ICZM in Practice

Mediterranean Sea:

Beginning in 2008, this ICZM protocol was the first adopted at the supranational level, and as a result, there was call for capacity building to implement the ICZM. With the intent to establish a knowledge base of ICZM capacities in the region and assess institutional integration, a comprehensive questionnaire (mentioned in step two of ICZM implementation) was developed and circulated. Since, the questionnaire was adapted to update existing information and a core set of 15 indicators for the Regional Seas to measure effectiveness of implementation of ICZM policies and programmes. They include: (1) added value per sector; (2) area of built-up space; (3) bathing water quality; (4) commercial fish stocks; (5) coastal and marine litter; (6) economic production; (7) employment; (8) erosion and instability; (9) natural capital; (10) hypoxia; (11) number of enterprises; (12) population size and density; (13) sea level rise; and (14) water efficiency index.

Black Sea:

While an earlier plan for the Black Sea Integrated Coastal and Shelf Zone Monitoring and Modeling Program was existing in 1999, it is unclear what the program achieved. Later, the Black Sea followed the Mediteranean ICZM Protocol and participated in a similar stock taking survey using the questionnaire (with results published in 2015). Finally, the Black Sea Regional ICZM Guidelines were written and accepted.

Wider Caribbean:

The Caribbean Environment Programme (CEP) serves as the Convention Secretariat for the Cartagena Convention which was adopted in 1983 and entered into force in 1986. By 1990, CEP identified a regional programme on Integrated Planning and Institutional Development for the Management of Marine and Coastal resources (IPD) in order to pilot ICZM and to establish a regional methodological framework document. Shortly after, to strengthen national competence and develop region-wide ICZM approaches, the Guidelines for Integrated Planning and Management of Coastal and Marine Areas in the Wider Caribbean Region were published. Currently, Integrating Water, and Ecosystems Management in Caribbean SIDs (GEF-IWECO) is being implemented to reduce pollution and improve land management.

Northwest Pacific:

NOWPAP was adopted in 1994 and since, the Pollution Monitoring Regional Activity Centre (POMRAC) established the Integrated Coastal and River Basin Management (ICARM) Working Group in 2007. Following the Working Group, several publications were developed to establish an overview of management, present experiences and lessons learned in member countries and build guidelines for users in the NOWPAP region. Respectively they include: the 2010 report, Regional Overview on Integrated Coastal and River Basin Management (ICRAM); Part 1 of the 2015 technical report on Integrated Coastal Planning and Ecosystem-based Management in the Northwest Pacific Region and Part 2 of the technical report.

ROPME Sea Area:

ROPME was established through the Kuwait Convention in 1979 and published its Guidelines on Integrated Coastal Areas Management in 2000. There has not been much evidence for action and successful implementation of ICZM within ROPME. National efforts are vital to integrate ICZM into planning and management at the national scale first in order to support ICZM development at the regional scale. Unfortunately, low reporting on ICZM at the national scale causes issues in understanding and supporting ICZM implementation at the regional scale.

Baltic Sea:

Within this region, there is no existing ICZM documentation, but there is information compiled on Maritime Spatial Planning (MSP) throughout the region. This information includes maps and documentation of the sea areas, national laws and regulations, governance, contact information, existing spatial plans and plans in development, and other relevant information for MSP. In 2016, the Guideline for the Implementation of Ecosystem-based Approach in Maritime Spatial Planning (MSP) in the Baltic Sea area was published and adopted by HELCOM. Prior to publication, a

Strategic Environmental Assessment (SEA) was conducted including public consultation and transparent information. This represents how the MSP process can feed into ICZM, being a broader process than ICZM, and can provide a tool to make target areas and interventions spatially explicit.

SDG Target 14.2 is broad and encompasses three objectives for marine and coastal ecosystems: 1) sustainable management and protection, 2) resilience, and 3) restoration. SDG Indicator 14.2.1 addresses the first objective: ecosystem-based approaches are a key element of sustainable management and encompass marine and coastal protection. The latter is further covered by SDG Target 14.5[35]. This overlap between SDG Targets 14.2 and 14.5 was noted during the country mission, by government representatives from Fiji, as a possible challenge for implementing the related SDG indicators. As the Fiji government representatives explained, it is not always clear whether conservation efforts are part of sustainable management or marine protection, and thus whether they should be counted towards SDG Target 14.2 or 14.5.2.

The objectives of resilience and restoration are not covered by SDG Indicator 14.2.1. Resilience and restoration are partially covered by ecological indicators and ecosystem-based monitoring programmes, like those under OSPAR (Northeast Atlantic), UNEP-MAP (Mediterranean Sea) and the EU Marine Directive, which provide information about the status and trends of marine and coastal ecosystems.

Other existing indicators for resilience and restoration tend to focus on individual marine and coastal habitats, such as coral reefs, seagrass, saltmarsh and mangroves. These individual indicators cannot be easily aggregated, making it difficult to develop a standardised indicator and methodology for resilience or restoration of marine ecosystems. One possible solution is to focus on a set number of regionally relevant critical habitats, for example the four 'critical habitats' identified by NOWPAP (Northwest Pacific) and CPPS (Southeast Pacific): mangroves, reefs, seagrass and saltmarsh. Once a small number of critical habitats is selected, countries could be encouraged to monitor and report on the status and trends of those habitats that happen to occur in their jurisdiction.

SDG Indicator 14.5.1

Text Box 7 summarises findings from the country missions to Fiji and Colombia on national efforts towards monitoring and reporting on marine protected area coverage to track progress against SDG Target 14.5.

Text box 7: Insights from the country missions on marine protected area coverage

Fiji: An ambitious national target

According to Protected Planet, 0.92% of Fiji's national waters are currently covered by protected areas: 11,953km^2 of a total marine area of 1,293,035km^2 (UNEP-WCMC 2018a). During the country mission, it was noted that data on Fiji's MPAs are submitted to the WDPA by the National Trust of Fiji, with plans for the Fiji Locally Managed Marine Areas, the Ministry of Environment and the Secretariat of the Pacific Regional Environment Programme to contribute information in the future.

Fiji has set itself an ambitious target to put 30% of its national waters under protection by 2020.

[35] SDG Target 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*

Colombia: A National Register of Protected Areas

In Colombia, the National Natural Parks (PNN in Spanish) is the national administrative body responsible for coordinating the national system of protected areas; collated data on protected areas are submitted to the WDPA. According to Protected Planet, 10.45% of Colombia's national waters are currently covered by protected areas: 76,392km^2 of a total marine area of 730,742km^2 (UNEP-WCMC 2018b).

All information related to protected area coverage is also made available by PNN on the National Register of Protected Areas (RUNAP in Spanish)[36]. RUNAP is a centralised protected area database on which Colombian environmental authorities can register protected areas under their jurisdiction, and upload information about these sites. PNN staff provide technical support and training where required to facilitate this process. The information uploaded into RUNAP includes metadata, geographic data and related images. RUNAP has an in-built validation and quality control process to ensure that all metadata and geographical data are accurate before being uploaded into the system. All data on protected area coverage are made freely available on the RUNAP website a month after a protected area has been declared. Data users can download geographic data in GIS (Geographic Information System) format (shapefile) and metadata as PDF (Portable Document Format).

Pilot testing acknowledgements

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[36] Colombia's National Register of Protected Areas (RUNAP): http://runap.parquesnacionales.gov.co/

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