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INTEGRATED SEASCAPE MANAGEMENT

Blue Economy

Data and Tools

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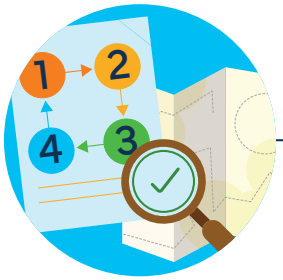
Contents

Acronyms 6

1. Introduction 7

Importance of data and tools in MSP 7



2. Methodology 9

3. MSP Data 10

MSP Data Categories 14

- Boundaries 17
- Physical / Chemical / Biological 18
- Activities and Uses 20
- Socio-Economic and Cultural 22

Data Gaps 23

4. MSP Tools 25

Software and Application Tools 26

Online GIS Mapping Tools and Portals 37

Other Tools 41

5. World Bank Data and Data Services 43

Data Development Hub (DDH) 43

Geospatial Operations Support Team (GOST) 44

ITS Technology & Information Lab 44

Knowledge Information and Data Services (KIDS) 44

6. Opportunity Areas for Engagement 45

Making the Case 45

Enabling Conditions 45

Planning 45

Implementation 47

Supporting Institutions 48

7. Conclusion 51

8. References 52

Other sources 53

Appendix A. Marine data tools (infrastructures) that were actually being used by EU MSP Planners 55

Appendix B. Data Management Framework and Protocols 58

Acronyms

ARIES	Artificial Intelligence for Environment & Sustainability
CCRES	Capturing Coral Reef & Related Ecosystem Services
DDH	Development Data Hub
DEVOTES	Development Of innovative Tools for understanding marine biodiversity and assessing good Environmental Status
DGA	Data Gap Analysis
ECR	Enabling Conditions Review
EEZ	Exclusive Economic Zones
EMODnet	European Marine Observation and Data Network
EO4SD	Earth Observation for Sustainable Development
EU	European Union
EWE	Ecopath with Ecosim
GEO	Group on Earth Observations
GOAP	Global Ocean Accounts Partnership
GOST	Geospatial Operations Support Team
I	Implementation
ICZM	Integrated Coastal Zone Management
IIED	International Institute for Environment and Development
IOC	Intergovernmental Oceanographic Commission
IPCC	Intergovernmental Panel on Climate Change
ITSTI	ITS Technology & Information
KIDS	Knowledge Information and Data Services
LSMS	Living Standards Measurement Study
M&E	Monitoring & Evaluation
MarLIN	Marine Life Information Network
MPA	Marine Protected Area
MSP	Marine Spatial Planning
MTC	Making the Case
NASA	National Aeronautics and Space Administration
ODEMM	Options for Delivering Ecosystem-Based Marine Management
P	Planning
SEEA	System of Environmental-Economic Accounting
TTL	Technical Team Leaders
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
USGS	U.S. Geological Survey
VRE	Virtual Research Environment
WAVES	Wealth Accounting and the Valuation of Ecosystem Services

1 Introduction

This chapter outline the importance of data and tools in Marine Spatial Planning (MSP), examines different aspects data and tools, general challenges and identifies how project managers, planners and implementers can support and add value to MSP projects.

Importance of data and tools in MSP

Data forms the backbone of any decision-making and planning process. Therefore, the type and quality of data you use in the process will directly impact the results of planning and implementation (Lodge et al., 2014; Albotoush et al., 2021). In some MSP resource material, data is also called 'evidence,' with the difference being that data intrinsically has no meaning for planning, but 'evidence' is for something relating to the planning process. Data or evidence can take many forms, including *"environmental, social or economic assessments, scientific advice, analysis of planning and management measures, marine monitoring or the use of geographic information systems and the data that underpins them"*[1].

1 Gov.uk (2018). Evidence and the Marine Management Organisation (MMO). Accessed Nov 2021.

MSP data (in particular geospatial data) tends to play a role in **3 specific ways** (European Commission, 2017):

1. Provides an overview of spatial distribution of human activities, marine ecosystems, and hotspots (e.g., species distribution maps, shipping density, wind areas, Marine Protected Areas (MPAs), etc.);
2. Identifies conflicts and shared space opportunities (e.g., user conflicts between fishers and shipping areas);
3. Allows spatial exploration of future economic and climate scenarios (e.g., different predictions under climate change scenarios).

Alongside the importance of available, usable, and good quality data for MSP, there is a need for planning and support tools to utilize the data fully. Tools are used for (i) spatial evaluation tools for assessment, impact and conflict analysis; (ii) guidance on how to factor ecosystem services into plans; (iii) analysis of the spatial dimension of future trends and related future scenario planning (European Commission, 2017).

Several tools exist but tend to be industry-specific and are therefore unable to integrate across sectors or are model-based, making it hard for stakeholder engagement and decision-support for non-technical persons (Steenbeek et. al., 2020). The 2016 review of European Union (EU) MSP activities noted that initial assessment tools were either (i) not used as they did not fit the purpose of 'real' MSP planners or (ii) MSP planners did not know about them or (iii) their potential scope was not known. The review also found that tools were utilized more in the project context and less in the consultation process (European Commission, 2017).

2 Methodology

The approach for this chapter was to perform a literature review on available research found using the keyword “marine spatial planning” and dating from 2001 to 2021. Additional searches were explicitly done for “data” and “tools” in MSP-related publications. The review was not limited to academic journals but also information and lessons learned from any available multilateral development banks, international development agencies, governments, global non-profits, research institutes, universities, and companies that may have conducted MSP-related activities. In addition, consultations were held with other authors of other Chapters of this work, e.g., MSP Economic Advisory Note, and WB personnel, e.g., Development Data Hub (DDH).

Note that ‘tool’ is a broad term and can refer to anything from a guidance document describing an approach to a highly technical model. This chapter focuses on ‘tools’ as any instrument that assists processes and can include information or guidance documents, data or mapping portals, or models.

Analysis of data needs and gaps and tool usability is based on secondary sources and can be considered a limitation. First-hand experience of tools would reveal a much more in-depth assessment and comparison of available tools; however, this was beyond the scope of this work. As such, the information provided in the sections below is to be used as guidance for Technical Team Leaders (TTLs) and other users as a stepping stone toward further exploration dependent on the specific features of the marine spatial plan context in question.

3
MSP Data

The data needs of a marine spatial plan are varied and depend on the unique characteristics of (i) geographical area (including transboundary factors), (ii) economic sectoral priorities, (iii) current stage of the MSP process (See Figure 1) (iv), the time frame of activities (including monitoring and evaluation), (v) participation level of stakeholders, (vi) types of available knowledge, (vii) need for justification of decisions (for example if needed at the court level) and (viii) level of integration pursued by the plan (McGowan et al., 2020; Said and Trouillet, 2020; Shabtay et al., 2020).

MSP decisions need to be guided by good quality baseline data, especially for situations where displacement occurs. This baseline data should include information on current and future activities and externalities. Generally speaking, there are a few key datasets considered essential for a basic MSP:

1. Administrative and political boundaries (e.g., Exclusive Economic Zones, EEZs)
2. Policy boundaries (e.g., MPAs)
3. Biological presence (e.g., location of coral reefs)
4. List of activities and users, preferably georeferenced (e.g., location of shipping channels)

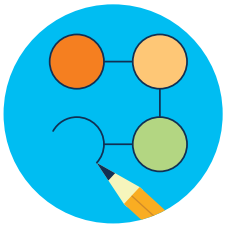
Data needs for MSP can also depend on the stage in the MSP process (Figure 1).

MTC

Making the Case:
Data needs at this stage should focus on the Blue Economy and ecosystem services to emphasize the need for sustainable management of activities. Baseline data demonstrating (i) the presence and status of ecological areas (e.g., mangroves and their current condition); (ii) social areas (e.g., communities and their level of dependence on ecosystem services); and (iii) economic activities (e.g., offshore wind energy) are essential to help identify the complexity (and therefore need for management) of the marine area. Ecosystem service valuations and non-spatial data are needed to identify marine spatial plan objectives and design. The MSP Economic Advisory Note, produced alongside this Chapter, provides a thorough analysis, particularly for using an economic lens to strengthen the case for MSP.

ECR

Enabling Conditions Review:
Information on sectorial policies, national policies, national development objectives, and existing frameworks are needed to conduct a regulatory and institutional review. Information on the availability and access to funding for planning and implementation will also drive the design process. This information is likely to be non-spatial information during this stage.



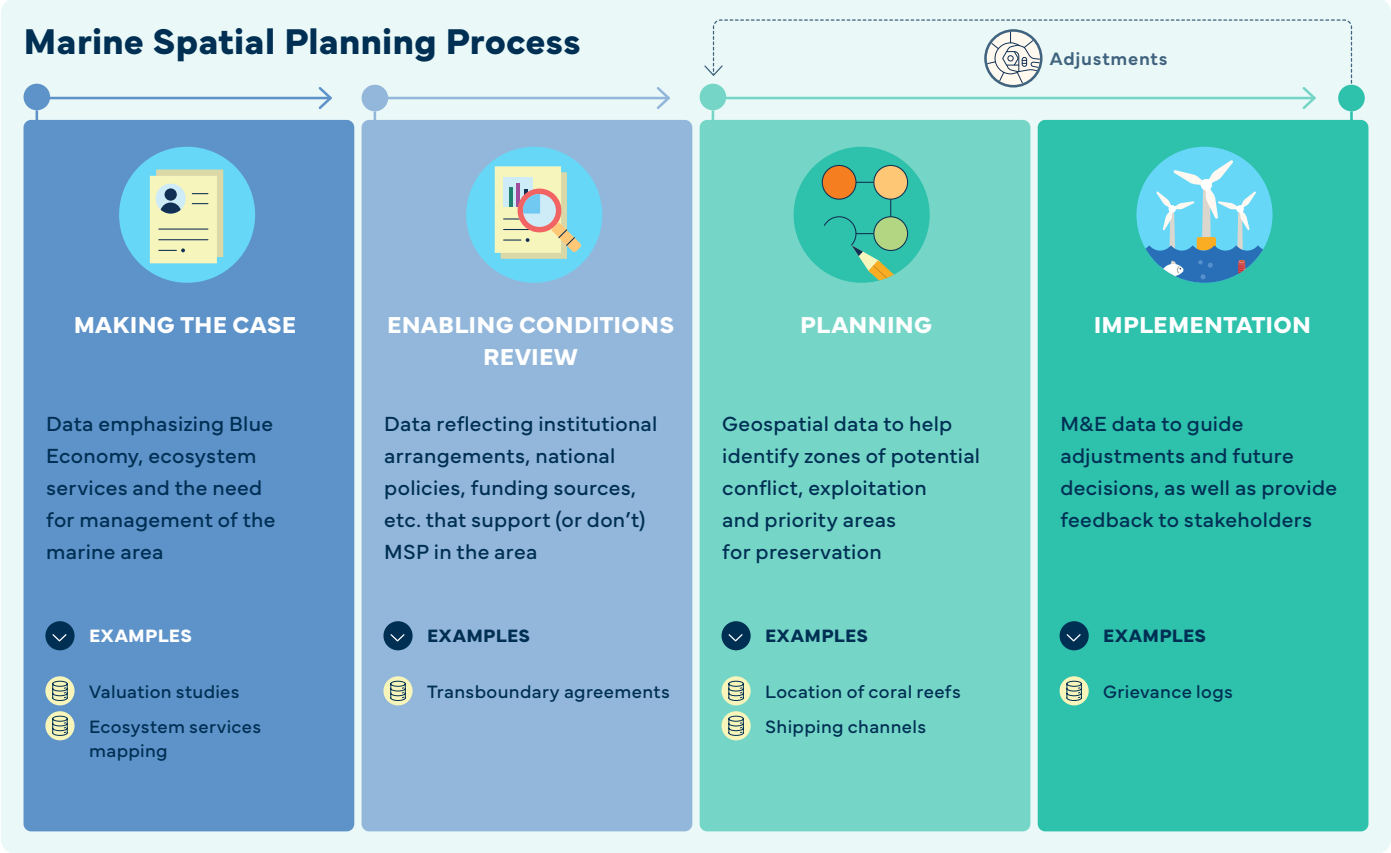
P

Planning:
This stage is where the bulk of the traditionally thought of data will play an important role, especially in determining the quality of model and tool outputs. Data needs will heavily depend on the sectors at play and geographical factors. Spatial information will be important as an input for models, such as those to analyze conflicts and synergies, impact assessments, user-environment interactions, etc. Many of these will also require future use and management data, including the impacts of climate change, industrial trends, etc.

I

Implementation:
Data needs here are for monitoring the area of interest and the plan's effectiveness. Adjustments to the marine spatial plan will be made based on monitoring and evaluation data.

Figure 1: Data needs and examples for each stage of the MSP process

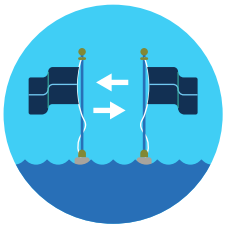


There are several considerations when using data for marine spatial plans:

Availability of data depends largely on the economic priorities of the area, with more prominent activities having more available data. Not all datasets will be available to fulfill the needs of a marine spatial plan and will therefore rely on the best available data at the time. MSP is complex, requiring data from marine, terrestrial, and climate zones, with the added complication of oceans also existing vertically with data at different depths. Data is often unavailable due to gaps which are addressed in a further section (European Commission, 2017).

Data compatibility is often a big challenge, more than the availability of data itself. Data collection is often done in sectoral silos and unable to cross over for use in other sectors or industries, leading to incompatibility and incomparability. The data is then unusable and

cannot contribute to the MSP process. The ability to reuse data is an important characteristic project manager needs to consider to save time and accelerate planning and scientific discovery (Flynn et al., 2020; Said and Trouillet, 2020; Tulloch et al., 2020).



Transnational data
is a common occurrence in the marine sector, as oceanic data has the possibility of crossing jurisdictional boundaries. This can make data collection and collective cooperation among a wide variety of parties more difficult. Transnational data challenges can include, for example, different data protocols and formats, different languages, and the lack of cooperation among the wide variety of parties – from high-level political to regional and local groups (European Commission, 2017; Tulloch et al., 2020; Albotoush et al., 2021).

Data collection
is as varied as the types of data. It is important to identify (i) purpose of data collection (e.g. stocktaking, mapping routes); (ii) who collected the data (e.g. governmental scientist, citizen scientist); (iii) types of data (e.g. spatial, non-spatial); and (iv) methodology (e.g. conventional scientific vs traditional local knowledge). All these factors can affect the usability of data for purposes other than what it was originally collected for (Said and Trouillet, 2020).

Data management
is often unstructured and inefficient for potential users and available only over unconnected databases or repositories managed by a wide variety of types of entities (e.g., government vs. scientific). Data collection is expensive and tends to take most of the budget, with little dedicated to management post-collection (García et al., 2020; Maragno et al., 2020; Tulloch et al., 2020).

Data quality
for MSP needs to be of a standard, acceptable quality, including clearly described metadata, the ability for use in web-based platforms, and at a scale or resolution suitable for the marine spatial plan in question. The quality of data will also affect its' ability to be analyzed and distilled into shareable knowledge.

MSP Data Categories

Four broad categories of MSP data can be identified and used throughout this chapter (See Figure 1). The level of inclusion for each of these data categories varies across marine spatial plans (European Commission, 2017):

Administrative boundaries:
present in most marine spatial plans

Physical / Chemical / Biological features and processes:
present in most marine spatial plans

Activities and Uses relating to the relevant human sectors:
tend to be present to some degree of detail in every plan, but vary on the diversity of data and the weight given to each sector, as well as whether or not activities include land-sea activities or exclusively sea activities.

Socio-Economic:
varies the most on whether or not it was included and to what extent. Trade-offs and economic valuation studies are very important here but may require a variety of methodologies that are specific to the context.

The below section outlines potential data needs, as identified in the literature review and consultations. It does not represent a comprehensive list and should be used as a guideline that would be modified to the local context, and based upon the specific activities and uses identified in the area of interest. This list is of use to project managers and TTLs to help identify necessary stakeholders to engage with, outline data needs, and demonstrate to clients the complexity and importance of interrelationships between users of marine space. Planners and implementers can utilize this list as a 'wishlist' for data needs, to identify important data gaps that need to be addressed in future data collection work, and to identify key data that should be monitored during the implementation of a marine spatial plan.

The data categories below (Figure 3) are organized in a three-tiered system, with more specific examples provided for each category. The potential depth or variety of data beyond this is extensive and beyond the needs of this product. For example, the below Figure 2 shows the hierarchy of Storm Activity, which can potentially be further broken down temporally (e.g., historical vs. future scenarios (European Commission, 2017), by intensity (e.g., tropical storm vs. hurricanes), or other factors.

Figure 2: Example of three-tiered data categorization used in this Chapter

Figure 3: Categories and examples of data needs for Marine Spatial Planning and Blue Economy

Administrative
National, Territorial, EEZ, ...

Policy
Priority areas, Globally recognized areas, MPAs, ...

Cultural
Cultural and artistic design, ...

Economic
Land and building values, ...

Social
Conflict Resolution, Demographic, Well-being, ...

Climate
Sea Level Rise, Shoreline erosion, Storm activity, ...

Biological
Habitat, Fisheries, Seabirds, ...

Physical
Bathymetry, Salinity, pH, ...

Pressures & Impacts
Dredging, Extraction, Pollution, ...

Coastal Defense
Coastal Engineering, Nature Based Solutions, ...

Underwater Cultural Heritage
World Heritage sites, Monuments, Wrecks, ...

Fisheries
Aquaculture, Fishing Effort, ...

Maritime Transport
Anchorages, Ferry, ...

Renewable Energy
Location, Depth, ...

Tourism & Recreation
Marinas, Tourism Areas, Blue Flag Awards, ...

Scientific Research
Research Areas, Monitoring Stations, ...

Submarine Cables & Pipeline Routes
Telecommunication, Pipelines, ...

Raw Material Extraction
Sand, Biotechnology, ...

Ports
Locations, Depth, Bunkering, ...

Military
Bases, Training Areas, ...

Installations & Infrastructure
Buoys, Bridges, ...

The below Table 1 highlights a list of potential data needs, and is meant to be used as a guideline and not a comprehensive checklist. Actual needs and availability will vary depending on the situation and context. The table also highlights which data could be useful for the different stages of the MSP process.

Table 1: Potential data needs for an MSP, including usefulness in each of the MSP process steps

				Useful for MSP Stage			
				Making the Case (MTC)	Enabling Conditions Review (ECR)	Planning (P)	Implementation (I)
Boundaries							
	**Administrative**	National				✓	
	Administrative	Regional				✓	
	Administrative	Local				✓	
	Administrative	Territorial			✓	✓	
	Administrative	EEZ		✓	✓	✓	
	**Policy**	Marine Management Areas	MPAs, reservations, no build, development, priority areas	✓		✓	
	Policy	Globally Recognised Area	Areas of high biodiversity value, World Heritage, Ecologically or Biologically Significant Areas, Important Marine Mammal Area, Particularly Sensitive Sea Area, Ramsar Site, UNESCO Biosphere	✓		✓	
	Policy	Intercoastal Zone Management Areas				✓	
	Policy	International and National legislation	Agreements, policies, regulations	✓	✓	✓	

Physical / Chemical / Biological				MTC	ECR	P	I
	**Physical Characteristics**	Seabed relief and bathymetry				✓	
	Physical Characteristics	Hydrodynamics	Oceanic currents			✓	
	Physical Characteristics	Wind and wave action	Wave height			✓	
	Physical Characteristics	Temperature	Land and Sea Surface Temperature, Urban Heat Islands			✓	
	Physical Characteristics	Turbidity	Sedimentation			✓	
	Physical Characteristics	Water transparency / Light				✓	
	Physical Characteristics	Salinity				✓	
	Physical Characteristics	Water masses and residence time				✓	
	Physical Characteristics	Nutrients and dissolved oxygen				✓	
	Physical Characteristics	pH, pCO2, sea acidification				✓	
	Physical Characteristics	Tidal flow				✓	
	Physical Characteristics	Water courses / watersheds	Dams, reservoirs, lakes			✓	
	Physical Characteristics	Land cover	Terrain			✓	
	Physical Characteristics	Shoreline change		✓		✓	✓
	**Climate Change**	Sea Level Rise		✓		✓	✓
	Climate Change	Ocean acidification				✓	✓
	Climate Change	Sea Surface Temperature changes				✓	✓
	Climate Change	Waves and tidal changes				✓	✓
	**Hazards & Disasters**	Storm activity	Historical hurricane paths, future predictions, storm surge			✓	✓
	Hazards & Disasters	Vulnerability assessments		✓		✓	✓
	Hazards & Disasters	Flooding	Urban flooding	✓		✓	

Physical / Chemical / Biological				MTC	ECR	P	I
	Biological Characteristics	Seabed	Substrate type	✓		✓	
	Biological Characteristics	Habitat presence	Estuaries, tidal flats, marshes, dunes, kelp beds, coral reef, mangrove, seagrass, nature-based solutions			✓	
	Biological Characteristics	Habitat status	Health assessments	✓		✓	
	Biological Characteristics	Water column				✓	
	Biological Characteristics	Angiosperms, macro-algae				✓	
	Biological Characteristics	Fisheries areas	Stock / population, spawning and nursery areas, fecundity, migration routes	✓		✓	
	Biological Characteristics	Marine mammal activity	Migration routes, breeding areas			✓	✓
	Biological Characteristics	Sea birds	Migration routes, wintering grounds, nesting areas			✓	✓
	Biological Characteristics	Species distribution	Invasive species tracking, species listed under community legislation or international conventions			✓	✓
	Biological Characteristics	Ecosystem service valuation and assessments		✓			
	Pressures and Impacts	Fisheries	Impact on ecosystems			✓	✓
	Pressures and Impacts	Dredging activities	Physical destruction, dumping of dredged material, chemical effects			✓	✓
	Pressures and Impacts	Extraction activities	Physical destruction, selected extraction of species and by-catch			✓	✓
	Pressures and Impacts	Eutrophication and algae blooms				✓	✓
	Pressures and Impacts	Underwater noise				✓	✓
	Pressures and Impacts	Introduction of synthetics and heavy metals				✓	✓
	Pressures and Impacts	Pollution	Ship ballast discharge, marine litter (plastics, solid waste), urban run-off			✓	✓

Physical / Chemical / Biological				MTC	ECR	P	I
	Pressures and Impacts	Introduction from anthropogenic sources	Radionuclides, microbial pathogens, non-indigenous species			✓	✓
	Pressures and Impacts	Land use (urban expansion)				✓	✓
	Pressures and Impacts	Invasive species distribution	Sargassum, Lionfish			✓	✓
	Pressures and Impacts	Waste management mapping	Mapping pollution, agricultural discharge, plastics and solid waste, ghost fishing gear			✓	✓

Activities and Uses				MTC	ECR	P	I
	**Fisheries**	Aquaculture	Designated aquaculture areas (offshore and inshore)				
	Fisheries	Fishing areas	Important fishery areas by species, fishery management areas, landing/ processing sites, harbours,			✓	
	Fisheries	Fishing effort	Number of vessels, capacity, fishing type (industrial/artisanal, species specific, vessel movements (vessel monitoring system and automated identification system data), fish aggregating devices,	✓		✓	✓
	Fisheries	Cultural	Indigenous fishing grounds, villages and routes, important to community	✓		✓	✓
	**Renewable Energies**	Location	Type of renewable energy (e.g. solar, wind, wave, etc.), proposed sites, total surface area covered, water depth, shortest distance to the coast			✓	
	Renewable Energies	Infrastructure	Number of turbines/other plants, cable landing points			✓	
	**Installations & Infrastructure**	Energy	Power stations, fuel storage, nuclear stations, electricity cables, buoys and pods (with link to Energy Production)			✓	
	Installations & Infrastructure	Transportation	Tunnels, bridges, masts, platforms			✓	
	Installations & Infrastructure	Benthic structures				✓	
	Installations & Infrastructure	Urban (Coastal) infrastructure				✓	

Activities and Uses				MTC	ECR	P	I
	**Maritime Transport Routes & Traffic Flows**	Routes and shipping areas	International Maritime Organization routes, local ferry lines, fairways, roadsteads, anchorages, dumping areas, capital and maintenance dredging areas, restricted areas			✓	✓
	Maritime Transport Routes & Traffic Flows	Global Shipping Traffic Density	Vessel-type, Automatic Identification Systems			✓	✓
	**Ports**	Locations	Total surface area covered, water depth, accessibility (slipways, berthing spots), bunkering			✓	✓
	Ports	Socio-economic	Direct and indirect employment, percentage of goods handled, percentage of turnover, total container transfer			✓	✓
	**Military**	Locations	Military training areas, radar areas / observation areas, munition disposal sites, military bases			✓	
	**Raw Material Extraction**	Active extraction sites	Sand and gravel, natural gas, oil, carbon, fracking, deep sea			✓	
	Raw Material Extraction	Storage	Sand and gravel, natural gas, oil, carbon, fracking			✓	
	Raw Material Extraction	Blue biotechnology				✓	
	**Scientific Research**	Locations	Research areas, measuring and monitoring stations or networks			✓	
	**Submarine Cables & Pipeline Routes**	Infrastructure	Telecommunication / data cables (in and not in use), high voltage cables, pipelines, underwater data centres			✓	
	**Tourism & Recreation**	Zones	Boating, nautical tourism, fisheries tourism, kiting, whale watching, eco-tourism			✓	
	Tourism & Recreation	Sites	Marinas, hotels, floating platforms, seascapes			✓	
	Tourism & Recreation	Distribution of tourists	Tourism density,			✓	
	Tourism & Recreation	Internationally recognized sites	Blue Flag awards			✓	

Activities and Uses				MTC	ECR	P	I
	**Underwater Cultural Heritage**	Internationally recognized sites	World Heritage sites, historically important sites			✓	
	Underwater Cultural Heritage	Sites	Wrecks, ruins, monuments			✓	
	**Coastal Defense**	Zones	Areas used for dredging			✓	
	Coastal Defense	Coastal engineering	Coastal protection schemes, artificial coastlines, flood defence schemes, nature-based solutions, managed realignment schemes			✓	
	Cross-cutting	Socio-economic	Direct and indirect employment by sector, current and future consumption, gross added value, economic importance	✓			✓

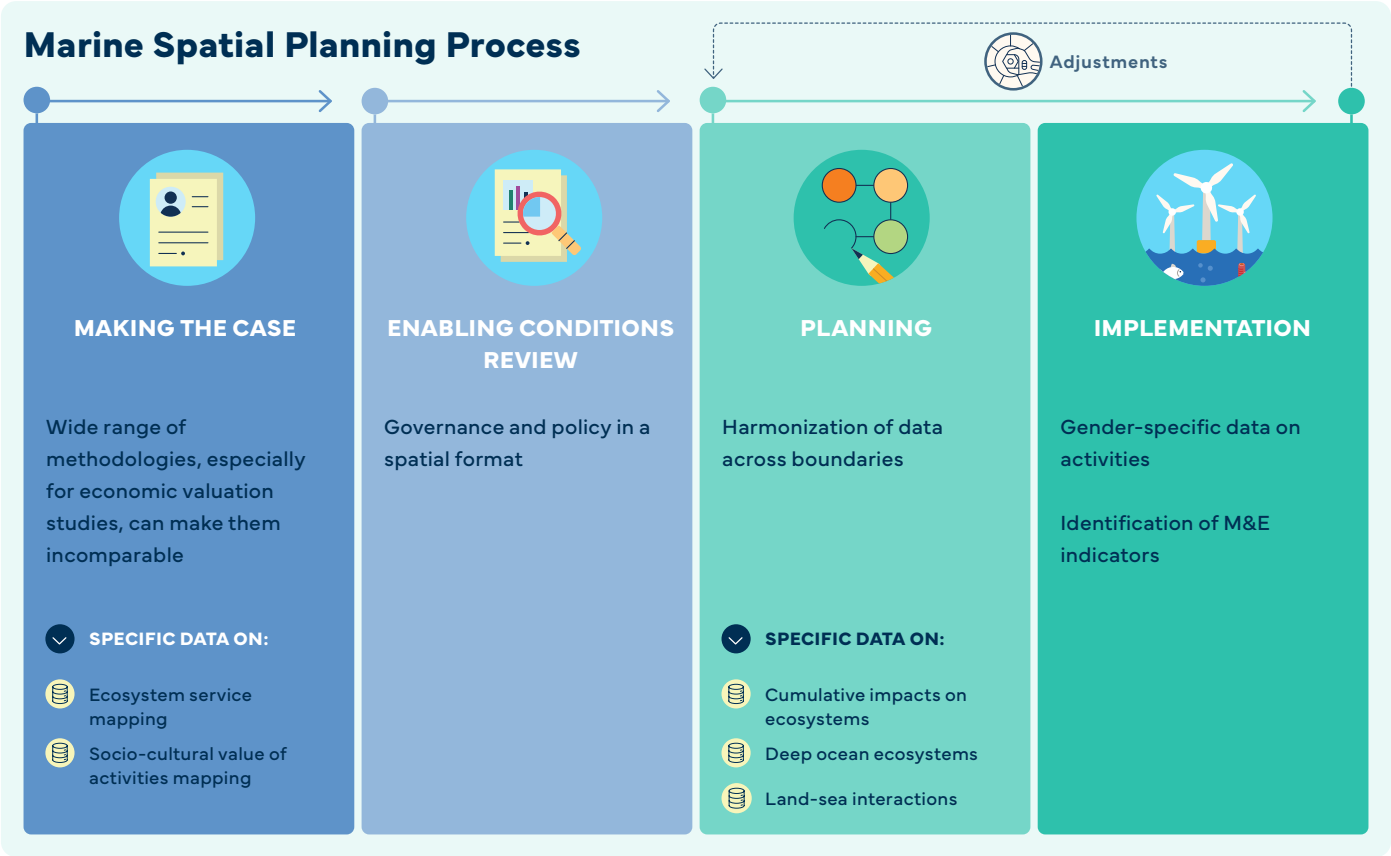
Socio-Economic and Cultural				MTC	ECR	P	I
	**Social**	Conflict resolution	Grievance logs, recorded types of conflicts	✓		✓	✓
	Social	Populations and Demographics	Gender, age, nationality, education	✓		✓	✓
	Social	Economic standing	Land ownership and cadastral, employment type, livelihood type, job generation, insurance and financial access	✓		✓	✓
	Social	Well-being	Food security, vulnerability	✓		✓	✓
	Social	Vulnerable groups	Gender, indigenous people, elderly	✓		✓	✓
	**Culture**	Important sites	Assets (wrecks, ruins, etc), cultural and recreational activities, important artistic designs	✓			✓
	**Economic**	Valuations	Current land, building, non-market values	✓			✓
	Economic	Analyses	Cost-benefit analyses, impact evaluation	✓			✓
	Economic	Ocean accounting		✓			✓

Data Gaps

Data gaps can exist on many levels but fundamentally are either due to (i) inexistence or (ii) inability to use existing data. That is, the data could be completely missing from any database, never having been collected before, or they could exist, but an essential element is missing (e.g., scale, language, geospatial representation, etc.) that renders it useless for analysis, interpretation or integration with other datasets.

Generally speaking, boundary data is in existence but may suffer 'gaps' or the inability to be used due to a lack of data harmonization. The data categories 'Physical / Chemical / Biological' and 'Activities & Uses' are generally well represented, but gaps lie in the level of detail and impacts. The biggest gaps identified are in Socio-Economic, Cultural and Governance data types. In many older MSP projects, they are not represented at all, and in newer ones represented only to a limited extent (European Commission, 2017). Some cited reasons for this gap include (i) the difficulty of representing this data spatially, (ii) the lack of defined methodology in collecting multiple forms of data for MSP; and (iii) compartmentalization of existing data, making the data not useful for marine components only (Said and Trouillet, 2020). Strategic data is less common than descriptive data, especially as it relates to future uses and activities and their associated impact (García et al., 2020; McGowan et al., 2020). Gaps can also be categorized by the MSP process (Figure 4).

Figure 4: Data gaps based on the MSP process



Geographically speaking, developing countries tend to lack available information across all categories and sectors. The global south has been identified as an area that lacks MSP progress, which is also reflected in the amount of MSP tools specific to the north or globally, rather than to the south. Some of the data is available at a broader scale (global or regional) rather than the needed local scale.

A Data Gap Analysis (DGA) specific to the MSP context should be performed by TTLs, managers, and planners as part of the MSP process and performed periodically during MSP implementation. A DGA is meant to identify actions to transition from current and ideal states of data availability. The ideal state can be defined by stakeholders and secondary literature. One such method for a DGA is outlined by the Global Biodiversity Information Facility's 'Best Practice Guide for Data Gap Analysis for Biodiversity Stakeholders' (Ariño et al., 2016). Table 1 above provides a good foundation to help identify data gaps by category.

4 MSP Tools

Although there are several relevant tools in existence, their use in MSP is not as prevalent. This chapter focuses on 'tools' as any instrument that provides assistance and can include information or guidance documents, data or mapping portals, or models. Some examples of types of tools used in MSP projects include (European Commission, 2017):

Applied modeling tools to support management:
A combination of a hydrodynamic model (SHYFEM) and a 3D sediment transport model (SEDTRANS05) were used in the EcoDump project (2011-2014) to help determine offshore dumping sites in the SE Baltic Region. Highly technical modeling tools are not described below in detail.

Conflict resolution:
The Maritime Use Conflicts Analysis score tool developed within the Adriplan project (2013-2015) allows for the quantification of overlapping uses, calculating the direct spatial conflict score (in the current and future scenarios) based on the COEXIST project methodology (see Tools4MSP in the table below).

Future scenario planning:
The study Options for Coastal Information Systems conducted an impact assessment for future EU Integrated Coastal Zone Management (ICZM) with a focus on social, economic, and environmental consequences.

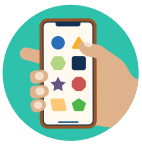
Decision support software for conservation planning:
Marxan was used in the Belize National Protected Area System Assessment and Analysis (2005) to assist as a planning tool for future protected areas.

Cumulative impact:
Symphony was a model-based tool developed for Sweden to support their implementation of the ecosystem-based marine spatial plan, specifically examining the effects of cumulative impacts and incorporating climate change.

Improving data harmonization and integration:
The project Bringing Together Land and Sea (BLAST, 2009-2012) focussed on improving merging information across the coastal margin in the North Sea region, which resulted in a series of datasets, tools, and applications.

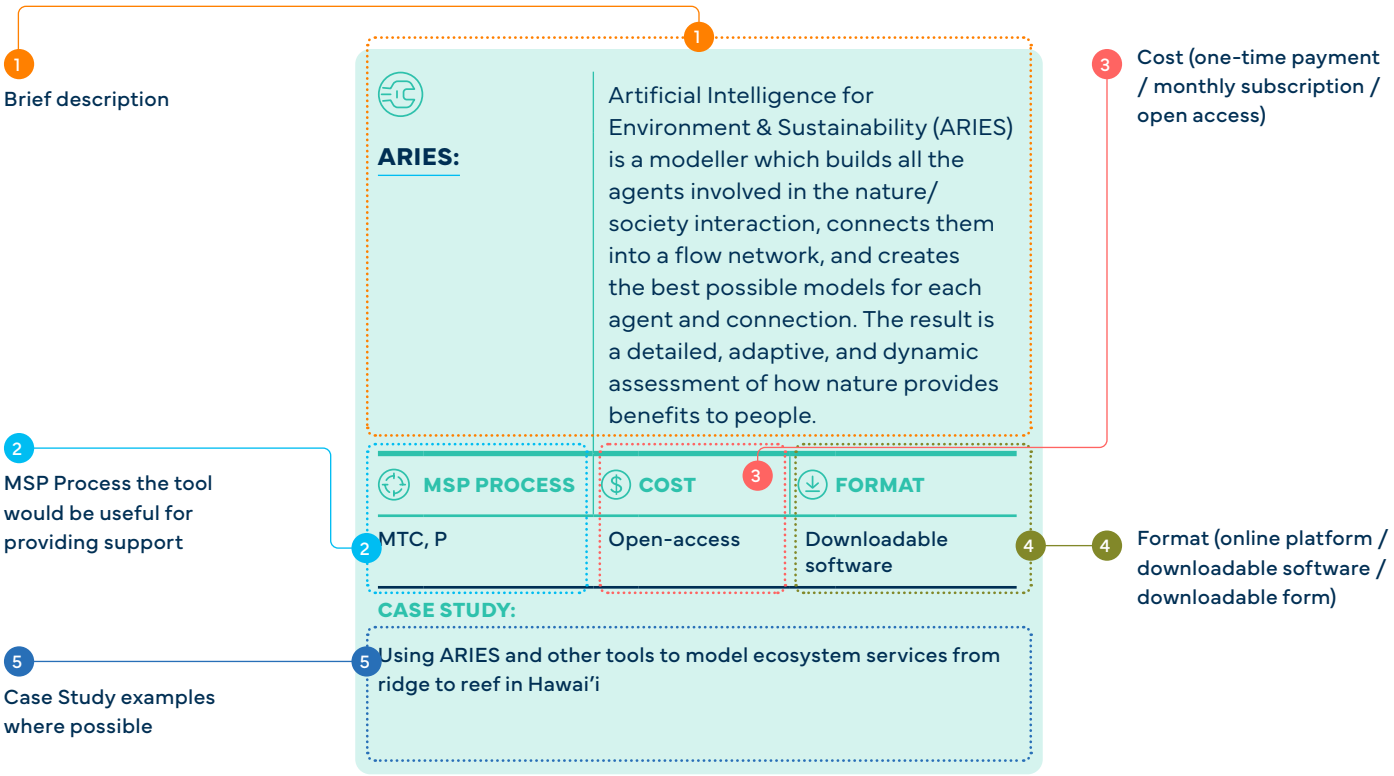
Providing intelligible visualizations to facilitate stakeholder engagement:
The Marine Spatial Challenge has used its products – Simulation Platform, Board Game, and 3D Oceans view to support the implementation of the Scottish National Marine Plan and participation in the development of Regional Marine Plans.

In a 2016 review of EU MSP projects, it was found that the majority of tools or infrastructures used were either Data Portals, GIS Mapping Tools, or Information Services, and mainly addressed the theme of describing the environment, followed by interactions in the marine environment.



Software and Application Tools

The below section presents an overview of several tools that have been used in MSP-related projects but should not be considered a comprehensive list. Information provided on tools, including advantages and disadvantages where given, is based on secondary sources. Each tool overview follows the below structure:



Adaptation Design Tool: Corals and Climate Adaptation Planning:

Developed through the Corals & Climate Adaptation Planning project, to help coral reef managers incorporate climate-smart design into their programs and projects at any stage of planning and implementation. The Tool can be used to incorporate climate change adaptation into management plans using existing planned actions as a starting point, and also to guide development of additional climate-smart strategies as needed. It includes worksheets, instructions, and examples as well as information on expanded considerations, resources and lessons learned to support managers in using the tool.

MSP PROCESS	COST	FORMAT
Planning	Open-access	Downloadable file

ARIES:

Artificial Intelligence for Environment & Sustainability (ARIES) is a modeller which builds all the agents involved in the nature/society interaction, connects them into a flow network, and creates the best possible models for each agent and connection. The result is a detailed, adaptive, and dynamic assessment of how nature provides benefits to people. The ARIES for SEEA Explorer is the first AI tool for rapid natural capital accounting (see below in Online GIS Mapping Tools).

MSP PROCESS	COST	FORMAT
Making the Case, Planning	Open-access	Downloadable software

CASE STUDY:

Using ARIES and other tools to model ecosystem services from ridge to reef in Hawai'i

Capturing Coral Reef & Related Ecosystem Services (CCRES) project tools

The Capturing Coral Reef & Related Ecosystem Services (CCRES) project (2014-2018) developed 16 technical tools and knowledge products to assist managers, policy-makers and planners improve the management of coastal ecosystems. These include the MPA and Fisheries Simulator, Rebuilding reef fisheries with MPAs toolbox, MPA placement optimization tool, MPA size optimization tool, Fish SPACE, Reef React, Coastal Protection, SESAMME, System Simulation Tool, SYSTORY, and FishCollab.

MSP PROCESS	COST	FORMAT
Planning, Implementation	Open-access	Downloadable software and web-based tools

CASE STUDY:

Two pilot projects, one in the Philippines and the other in Indonesia.

Changing Tides: Climate Adaptation Methodology for Protected Areas

This manual and set of associated worksheets describes an approach for developing climate adaptation measures in coastal and marine protected areas. It walks users through identifying ecological, ecosystem service, and socio-economic targets; collating information on baseline conditions; assessing vulnerability of the protected area; developing scenarios of likely changes as a result of threats; and validating vulnerability assessment results with stakeholders. The end result is the identification of potential impacts and prioritization of possible adaptation actions to address these impacts.

MSP PROCESS	COST	FORMAT
Planning, Implementation	Open-access	Downloadable file

Climate Adaptation Toolkit for Marine and Coastal Protected Areas

This kit, created through EcoAdapt, was created to make climate adaptation planning a simple, direct, and feasible process for marine protected area managers. It contains tools that help protected area managers evaluate the vulnerability of their sites to climate change, identify appropriate adaptation strategies and learn about those strategies through case studies, reports and other resources.

MSP PROCESS	COST	FORMAT
Planning, Implementation	Open-access	Downloadable software

Coastal Climate Adaptation Decision Support

is an iterative decision support process, developed through the CoastAdapt, to support climate change adaptation planning and implementation on the Australian coast, but many aspects are applicable globally. It includes guidance, tools, case studies, templates and other resources. It supports building organizational buy-in, communicating and engaging effectively with stakeholders, and understanding financing options. The tool is designed to reach a variety of audiences at different levels.

MSP PROCESS	COST	FORMAT
Planning, Implementation	Open-access	Downloadable file

Decision Support Tool for Blue Economy in Marine Protected Areas

supports the operationalization of the recommendations produced within the Interreg MED PHAROS4MPAs project, translating the knowledge from the capitalization baselines reports into a fully user-friendly online tool. The tool is specifically intended for MPA managers and planners, public authorities and economic operators, to help them to easily find the recommendations and other information (e.g. best practices or case studies) that are more useful for their specific needs.

MSP PROCESS	COST	FORMAT
Planning, Implementation	Open-access	Downloadable software

CASE STUDY:

The PHAROS4MPAs project explores how Mediterranean MPAs are affected by maritime activities and provides a set of practical recommendations on how the environmental impacts can be prevented or minimized.

DEVOTES

The DEVelopment Of innovative Tools for understanding marine biodiversity and assessing good Environmental Status (DEVOTES) project (2012-2016) aimed to support the implementation of the MSFD in European waters. The project included development of the DEVOTool catalogue of biodiversity indicators, and the Nested Environmental Assessment Tool (NEAT), along with a smartphone app and two other catalogues.

MSP PROCESS	COST	FORMAT
Planning, Implementation	Open-access	Downloadable software

CASE STUDY:

Developed through the DEVOTES project, aimed at improving understanding of human activities impacts (cumulative, synergistic, antagonistic) and variations due to climate change on marine biodiversity, using long-term series (pelagic and benthic).

Earth Blox

an analysis tool designed to simplify earth observation and remote sensing; includes Earth Blox for Education project.

MSP PROCESS	COST	FORMAT
Planning, Implementation		Online, cloud-based

EcoImpact Mapper

an easy-to use open source software tool for mapping human impacts on marine ecosystems. It is based on the additive human impact model suggested by Halpern et al. (2008).

MSP PROCESS	COST	FORMAT
Planning, Implementation	Open-access	Downloadable software

CASE STUDY:

Advancing marine cumulative effects mapping: An update in Canada's Pacific waters (Murray et al., 2015)

Ecopath with Ecosim (EwE)

a modelling software suite comprised of *Ecopath* – a static, mass-balanced snapshot of the system; *Ecosim* – a time dynamic simulation module for policy exploration; and *Ecospace* – a spatial and temporal dynamic module primarily designed for exploring impact and placement of protected areas; increasingly used to assess the effects of environmental change on marine ecosystems for policy advice.

MSP PROCESS	COST	FORMAT
Making the Case, Planning, Implementation	Open-access	Downloadable software

CASE STUDY:

An Ecopath with Ecosim Analysis on Offshore Platform Influences on Gulf of Mexico Red Snapper (Gomez, 2020)

☆☆☆☆☆

Tool Review No. 1

Ecopath with Ecosim (EWE)

Advantages:

Open-access, downloadable file; widely used with good user support; constant improvements (e.g. the addition of a dynamic geospatial data exchange framework has opened up Ecospace to increased realism); important characteristics (e.g. geographic boundaries) can be incorporated into the simulation platform solely through data input without requiring software changes, thereby making it possible to develop new regional editions within an acceptable time frame and budget.

Disadvantages:

Constraints associated with fast model runs; simplified definitions / categories / systems (e.g. lack of variety of artificial substrate types); use of simple linear response functions rather than evidence-based elaborate response curves was a simplification born out of a lack of data for all species included in functional group aggregations.

Case Study Details on next page

Case Study Details:

Offshore oil and gas platforms have had a significant presence in the Gulf of Mexico since the 1950s. An important secondary function of these structures is that they provide artificial habitat to fisheries, most notably Red snapper. Policy changes intended to reduce the risk associated with aging infrastructure have reduced the number of standing platforms from 4044 to 1867 from 2001 to 2018. The effect this loss of habitat has on Red snapper was tested by creating three scenarios of platform changes and modeling the perturbation from 2005 to 2050. The simulation was accomplished using the ecological model EWE where Ecosim executes the time dynamic portion of the model and Ecopath provides the initial mass balanced information for all species in the system. Fecundity estimates were used on a per platform basis and imposed on the egg production parameter of the Ecosim model to complete the scenarios. Results showed Red snapper fecundity on platforms to be relatively low resulting in minor changes in biomass for all three scenarios of offshore platform change. The most notable differences were in the types of vulnerability estimations used which dictates the interaction between organisms in the model. Based on these parameters offshore platforms were not seen to be a major contributor to Red snapper populations in any scenario or estimation method (Abstract, Gomez, V. (2020).

(Source: Christensen and Walters, 2004)

EO4SD Marine and Coastal Resources Portfolio

offers a series of services – Support for MPA management, Coastal habitat mapping, Coastal bathymetry mapping, Shoreline mapping and change detection, Benthic habitat mapping, Coastal land use change, Water quality

MSP PROCESS	COST	FORMAT
Planning	Unknown	Advisory Service

ExtendSIM

is a simulation software used for decision-making in a number of fields, including engineering, environmental management, and public policy, allows for better understanding of how natural systems react to changing conditions, including anthropogenic impacts.

MSP PROCESS	COST	FORMAT
Planning, Implementation	Licenses must be purchases; additional packages available	Downloadable software

CASE STUDY:

The SPICOSA simulation effort represents the first comprehensive quantification of the marine ecosystem linked to relevant socio-economical components. The multidisciplinary modeling of Mar Piccolo utilized the ExtendSIM simulation software (Caroppo et. al., 2011).

Google Earth 3D Timelapse Tool

presents a global, zoomable time-lapse video of the planet from 1984 to 2020, based on U.S. Geological Survey (USGS) Landsat satellite data and imagery. Imagery is for land use, above surface only and not able to accurately show changes in underwater.

MSP PROCESS	COST	FORMAT
Making the Case, Planning	Open-access	Online Google Earth Extension

Guide for Planners and Managers to Design Resilient Marine Protected Area Networks in a Changing Climate

developed through the project Engaging Communities to Conserve Marine Biodiversity through the North American Marine Protected Areas Network, this guide uses scientific information gathered on the impact of climate change on MPA networks to improve the design and management process for healthier, more resilient oceans. It provides steps for meeting four climate change goals.

MSP PROCESS	COST	FORMAT
Planning	Open-access	Downloadable File

iMarine

a collaborative initiative aimed at supporting the implementation of the Ecosystem Approach to fisheries management and the conservation of living marine resources. It provides an e-infrastructure that facilitates open access and the sharing of a multitude of data, collaborative analysis, processing and mining processing, as well as the publication and dissemination of newly generated knowledge. It offers four 'bundles' of applications, each with 2-6 related applications; and have developed over 15 Virtual Research Environment (VREs) that combine several of the applications.

MSP PROCESS	COST	FORMAT
Planning, Implementation	Open-access, requires registration	Downloadable software

CASE STUDY:

The Vessel Activities Analyzer (VRE) allows users to manage vessel trajectories, alongside additional information such as bathymetry, fishing areas, etc.

Living Standards Measurement Study (LSMS)

the World Bank's flagship household survey program focused on strengthening household survey systems in client countries and on improving the quality of microdata to better inform development policies. The overarching goal of the LSMS is to foster the development and facilitate the adoption of new methods and standards in household data collection for evidence-based policymaking. The LSMS data are publicly available and open access through the World Bank Microdata Catalogue.

MSP PROCESS	COST	FORMAT
Making the Case, Planning	Open-access	Downloadable guides

Marxan

a widely used conservation planning tool supporting the design of marine and terrestrial reserves worldwide. Used for design of new systems, reporting on the performance of existing systems, developing multi-use zoning plans for natural resource management.

MSP PROCESS	COST	FORMAT
Making the Case, Planning, Implementation (Adjustments)	Open-access	Downloadable software

CASE STUDY:

Marxan was applied as a support tool to identify suitable sites for offshore wind power in the pilot area Pomeranian Bight / Arkona Basin in the western Baltic Sea (Göke et. al., 2018).

Tool Review No. 2

Marxan

Advantages:

Explicit target setting, integrate costs (limited), fairly unique analysis, simulated annealing concept / optimizing algorithm, transparency, systematic methodology, ability to explore scenarios, insights into trade-offs, multiple options (for complexity), no data assumptions, handles many data layers, transparency for planners and stakeholders, easy to work with and free

Disadvantages:

Connectivity challenging to integrate, cost function not helpful, not all MSP questions can be solved by optimizing, high level of expertise necessary, strict data requirements, calibration is demanding, scale of different input data and study area, difficult parameterization, approximation / assumptions, no option to have biological and hydrodynamic processes, climate change etc. directly included, impacts not predefined, misleading interpretation if not performed properly, communication with stakeholders, difficult to explain, overly complex, lacks user-friendly interface, resource demanding

Case Study Details:

The development of offshore wind energy and other competing interests in sea space are a major incentive for designating marine and coastal areas for specific human activities. Maritime Spatial Planning (MSP) considers human activities at sea in a more integrated way by analysing and designating spatial and temporal distributions of human activities based on ecological, economic and social targets. However, specific tools supporting spatial decisions at sea incorporating all relevant sectors are rarely adopted. The decision support tool Marxan is traditionally used for systematic selection and designation of nature protection and conservation areas. In this study, Marxan was applied as a support tool to identify suitable sites for offshore wind power in the pilot area Pomeranian Bight / Arkona Basin in the western Baltic Sea. The software was successfully tested and scenarios were developed that support the sites indicated in existing national plans, but also show options for alternative developments of offshore wind power in the Pomeranian Bight / Arkona Basin area (Abstract, Göke et. al., 2018)

(Source: Janßen et. al., 2019)

Monitoring climate-related responses in Mediterranean Marine Protected Areas and beyond

five standard protocols: developed through the Interreg MED Program, these protocols provide guidance for tracking climate-related impacts in Mediterranean MPAs and beyond. It includes an e-learning unit, video tutorials, presentations, standard protocols, and files for data inputs.

MSP PROCESS	COST	FORMAT
Planning, Implementation	Open-access	Downloadable file

Natural Capital Project

aims to improve the well-being of people and our planet by motivating targeted investments in nature.

MSP PROCESS	COST	FORMAT
Making the Case, Planning, Implementation	Open-access	Downloadable software

CASE STUDY:

Modeling benefits from nature: using ecosystem services to inform coastal and marine spatial planning (Guerry et al., 2012).

Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST)

a suite of free, open-source software models used to map and value the goods and services from nature that sustain and fulfil human life. InVEST enables decision makers to assess quantified trade-offs associated with alternative management choices and to identify areas where investment in natural capital can enhance human development and conservation. This tool is well suited for coastal and marine spatial planning.

Restoration Opportunities Optimization Tool (ROOT)

a tool to perform optimization and tradeoff analysis. It uses information about potential impact of restoration or management change activities together with spatial prioritization or serviceshed maps to identify key areas for ecosystem service provision.

Offset Portfolio Analyzer and Locator (OPAL)

a tool for quantifying the impacts of development and the value of potential protection or restoration activities to biodiversity and ecosystem services.

Mapping Ecosystem Services to Human well-being (MESH)

an integrative modelling platform that calculates and maps ecosystem service supply under different landscape management scenarios.

North American Marine Protected Area Rapid Vulnerability Assessment Tool

was created to help MPA managers evaluate the implications of climate change for the habitats of their sites. This tool includes a user guide, worksheets and sample worksheets. They can help MPA managers conduct a rapid vulnerability assessment and adaptation strategy development process.

MSP PROCESS	COST	FORMAT
Planning, Implementation	Open-access	Downloadable file

ODEMM

based on the European Commission 7th framework funded project Options for Delivering Ecosystem-Based Marine Management (ODEMM), which generated and provided resources and knowledge that were tested in European regional seas but are adaptable to any marine managed area. The tools are still accessible upon request, though are not actively updated.

MSP PROCESS	COST	FORMAT
Making the Case, Planning	Open-access	Downloadable file

Linkage Framework

tool to understand the pathways through which sector-activities affect ecological components. The Linkage Framework can help with decision support and visualisation of the system.

Nested Governance Structures

outline structure can be used as a tool to explore who are the relevant bodies at each level of governance, and how do they connect to each other, for any specific issue.

Alternative Governance Models

models were developed to facilitate thinking about the options and possibilities of stakeholder involvement and regional cooperation and collaboration.

Pressure Assessment

tool to assess and rank the threat associated with any particular sector/pressure combination on any ecological component. This tool follows on from the Linkage Framework outputs by helping to determine which sectors and activities to prioritise for management.

Cost Benefit Analyses

decision-making tool that can inform policy-making. ODEMM has developed key resources to facilitate CBA including typologies of costs and benefits, and methods to compare the implications of different management options.

Ecological Risk Assessment

uses an exposure-effect analysis of the pressure assessment's categorical scoring of the interactions between human activities, pressures and components of the ecosystem, to assess the risk to ecosystems.

Integrated Management Strategy Evaluation (iMSE)

decision-support tool and comprehensive framework that aims to provide guidance for the identification and selection of consistently defined management options and allows an evaluation of these options to achieve policy objectives through their reduction of risk.

Reef Resilience Toolkit

connects coral reef and MPA managers and practitioners with information, experts, and resources to improve global coral reef health, restoration of reef fisheries, and community-based climate adaptation efforts. It includes scientific information, management tools and techniques, journal articles and case studies. The toolkit serves as a gateway to the Reef Resilience Network.

MSP PROCESS	COST	FORMAT
Planning	Open-access	Downloadable file

The Marine Spatial Planning Challenge

uses advanced game technology and aspects of gameplay to engage and facilitate planners and stakeholders, as they learn to manage the maritime (blue) economy and marine environment, thus facilitating ecosystem-based MSP. Provided are simulation platform, board game, and 3D oceans view; some of which are still under development.

MSP PROCESS	COST	FORMAT
Making the Case, Planning	Open-access	Downloadable file

CASE STUDY:

The BalticLINes project on transnational trends in Shipping and Energy used the MSP Challenge software, to increase awareness among MSP stakeholders, as well as to discuss these future trends with the stakeholders more intensively[2].

2 MSP Platform (n.d.) MSP Challenge simulation game. Accessed 24 Nov 2021.

Tools4MSP

are a set of web and open source tools developed to support the implementation of MSP, with a specific focus on the analysis of conflicts between marine uses and the analysis of cumulative impacts of human activities on marine environments. The Tools4MSP portal also hosts data layers and maps. There are four tools available.

MSP PROCESS	COST	FORMAT
Making the Case, Planning	Open-access	Online platform

CASE STUDY:

The Adriatic Ionian Maritime Spatial Planning (ADRIPLAN) project utilized these tools during their 18-month project.

Cumulative Effects Assessment Tool

assesses the potential cumulative impacts of maritime activities on the marine environment, and can be used for cumulative impact maps, sea use overlay analysis maps, and visualization of statistical results.

Maritime User Conflict Tool

can be used for the following tasks overlay analysis of sea uses, calculation of direct spatial conflict scores, development of current and future sea use scenarios and visualization of statistical results. Previously known as the COEXIST tool that was developed for the COEXIST Project.

Marine Ecosystem Services Threat (MES-Threat) Assessment

combines the expert-based MES supply index with the CEA modelling capabilities generating a threat index describing the risk of reduction of ES capacity, loss or impairment of use due to cumulative effects from anthropogenic impacts.

Decision Support Tool for Blue Economy in Marine Protected Areas

explores how MPAs are affected by activities in the growing Blue Economy, and provides a set of practical recommendations. This tool was developed for the PHAROS4MPAs project in the Mediterranean.

Online GIS Mapping Tools and Portals

These facilitate the sharing of information or simple analysis for users. Some of these have transitioned into operational systems. Some offer the ability to download data, others only static maps.

ArcGIS Online

a cloud-based software to create and share interactive web maps. The Marine Cadastre is an ArcGIS online group that provides oceans data, offshore planning tools, and technical support to the offshore renewable energy community. It has three primary focus areas: Web map viewers and oceans planning tools; spatial data registry; and technical support and regional capacity building.

MSP PROCESS	COST
Making the Case, Planning, Implementation	Pricing options available

ARIES for SEEA Explorer

enables users anywhere in the world to produce rapid, standardized, scalable and customizable ecosystem accounts for their area of interest that are consistent with the SEEA Ecosystem Accounting framework. ARIES for SEEA is available on the UN Global Platform, a cloud-service platform supporting international collaboration in the development of official statistics using new data sources and innovative methods[3]. Can be used either online or as a downloadable software.

MSP PROCESS	COST
Making the Case	Open-access

Baltic Explorer

a multi-user, multi-platform collaborative Spatial Decision Support System that allows for group work in Maritime Spatial Planning in the Baltic Sea region.

MSP PROCESS	COST
Making the Case, Planning	Open-access

Caribbean Marine Atlas

an online digital platform that stores and provides access to geospatial information (and related documents) on the "Marine Environment and Human Societies in the Wider Caribbean Region".

MSP PROCESS	COST
Making the Case, Planning	Open-access

3 Aries (n.d.) Aries for SEEA Explorer.

Caribbean Marine Maps

Portal from The Nature Conservancy that provides maps as satellite imagery, airborne imagery, drones and divers, Mapping Coral from Outer space to Undersea and Maps In Action.

MSP PROCESS	COST
Making the Case, Planning	Open-access

Climate Engine

a Google Earth Enterprise tool which offers on-demand cloud computing and data visualization of climate and remote sensing data, especially for decision support related to drought, water use, agriculture, wildfire and ecology.

MSP PROCESS	COST
Making the Case, Planning	--

Coastal Explorer (Belgium)

hosted by Flanders Marine Institute, this tool provides an overview of the Belgian coast, mainly as a static communication tool for a broad audience, and is an interactive and dynamic planning and mapping tool that will support decision-making on the Belgian coast. Interactive maps, static maps, downloadable metadata and other resources are available at this portal. It also features "CoastSnap" which is a global citizen science project that aims to engage citizens to participate in scientific research on the accretion and erosion of fixed location beaches.

MSP PROCESS	COST
Making the Case, Planning, Implementation	Open-access

Coastal Resilience

this portal from The Nature Conservancy examines nature's role in reducing coastal flood risk.

MSP PROCESS	COST
Making the Case, Planning	Open-access

Earth Map

offers the power of Earth Engine but with less coding requirements, and developed through a Food and Agriculture Organization of the United Nations (FAO) - Google partnership.

MSP PROCESS	COST
Making the Case, Planning	Open-access

European Atlas of the Sea

hosted by the European Commission, this provides information about Europe's marine environment. Users can view predefined and ready to use maps, covering topics such as nature, tourism, security, energy, passenger transport, sea bottom, fishing stocks and quotas, aquaculture, and much more.

MSP PROCESS	COST
Making the Case, Planning	Open-access

Google Earth Engine

combines a catalogue of 37 years of satellite imagery and geospatial datasets with planetary-scale analysis capabilities, allowing users to detect changes, map trends and quantify differences on the Earth's surface.

MSP PROCESS	COST
Making the Case, Planning	Open-access

IPCC WGI Interactive Atlas

A novel tool for flexible spatial and temporal analyses of much of the observed and projected climate change information underpinning the Working Group I contribution to the Sixth Assessment Report, including regional synthesis for Climatic Impact-Drivers.

MSP PROCESS	COST
Making the Case, Planning	Open-access

Marine Protection Atlas

is hosted by Marine Conservation Institute and is a comprehensive global database of marine protection based on self-reported data submitted by countries to the official World Database on Protected Areas (WDPA), and includes the MPA Guide Framework.

MSP PROCESS	COST
Making the Case, Planning	Open-access

MESH Seabed Habitat Maps (EMODnet)

provides a permanent single portal for accessing seabed habitat data in Europe. This includes the EMODnet broad-scale seabed habitat map for Europe (AKA EUSeaMap) and habitat maps from surveys across Europe. Tool was used by SIMCelt to compile an inventory of available datasets that could be readily used for a proposed Maritime Spatial Plan in the Celtic Sea[4].

MSP PROCESS	COST
Planning, Implementation	Open-access

Ocean+ Habitats

a living platform from United Nations Environment Program – World Conservation Monitoring Program, providing the world's decision-makers and communities of practice with the best possible global information, knowledge and tools required to manage and conserve ocean ecosystems.

MSP PROCESS	COST
Planning	Open-access

4 Emodnet (n.d.) Seabead Habitats. Acccessed 12 December 2021.

Ocean Wealth Explorer

a live mapping portal resource for sharing understanding of the value of marine and coastal ecosystems to people. It includes global maps, regionally-specific studies, reference data, and a number of "apps" providing key data analytics. Part of the Bahamas Protected project involved developing a Marine Protection Plan to expand The Bahamas Marine Protected Areas Network. The results can be viewed on the Ocean Wealth Explorer.

MSP PROCESS	COST
Making the Case, Planning	Open-access

PEDDR Opportunity Mapping Tool

highlights areas where ecosystem restoration and / or protection can be used to protect the greatest number of people globally, by overlaying global datasets on ecosystem distribution and hazard exposure. Currently three ecosystem-hazard combinations exist for viewing: coral reef opportunities to reduce coastal risks, mangrove opportunities to reduce coastal risks, and forest opportunities to reduce disaster risks. Datasets are available for download in TIFF format.

MSP PROCESS	COST
Making the Case, Planning	Open-access

SeaSketch

an online participatory mapping platform designed to allow planners and stakeholders to interact with data related to MSP processes. The tool can be customized to both large and small-scale planning projects to include options such as data sharing, scenario planning, message boards, analytical functions and other engagement methods. One of the objectives of the tool is to provide user-friendly access to maps and map data relevant to MSP.[5] The Barbuda Blue Halo Initiative used SeaSketch to engage almost every resident of Barbuda in the collaborative design of a zoning plan.[6]

MSP PROCESS	COST
Making the Case, Planning	License

Spatial Agent

a World Bank application that visualizes available spatial and temporal development-related data on an interactive mobile platform. It pulls together thousands of types of data from more than 300 web services from major institutions—United Nations Organizations, National Aeronautics and Space Administration (NASA), European Space Agency, World Bank, universities, and many more.

MSP PROCESS	COST
Making the Case, Planning	Open-access

5 Marine Planning (n.d.) Seasketch. Accessed 24 February 2022.
6 Seasketch (n.d.) Case Study Barbuda. Accessed 24 February 2022.

Tools4MSP Geoplatform

(formerly ADRIPLAN Portal) is a community-based, open source portal based on GeoNode, a web-based Content Management System for developing geospatial information systems and for deploying spatial data infrastructure. It host four tools (see above). The Adriatic Ionian Maritime Spatial Planning (ADRIPLAN) project utilized these tools during their 18-month project.

MSP PROCESS	COST
Making the Case, Planning	Open-access

The World Bank Maps

provides an interactive map interface for viewing The World Bank projects and datasets.

MSP PROCESS	COST
Making the Case, Planning	Open-access

Other Tools

AI Tool for Rapid Natural Capital Accounting

launched through the UN, this innovative artificial intelligence (AI) tool can vastly accelerate implementation of the new ground-breaking standard for valuing the contributions of nature that was adopted by the UN Statistical Commission. The tool makes use of AI technology using the Artificial Intelligence for Environment and Sustainability (ARIES) platform to support countries as they apply the new international standard for natural capital accounting, the System of Environmental-Economic Accounting (SEEA) Ecosystem Accounting.

MSP PROCESS	COST	FORMAT
Making the Case, Planning	Unknown	Unknown

Ocean Accounts Diagnostic Tool

From the Global Oceans Accounts Partnership, this tool is designed to engage and guide structured dialogue among stakeholders – data users, producers and holders – for strategically implementing and advancing ocean accounts.

MSP PROCESS	COST	FORMAT
Making the Case, Planning	Open-access	Downloadable Microsoft Word form

CASE STUDY:

5 pilot studies in Asia and Pacific

System of Environmental Economic Accounting (SEEA)

a United Nations framework that integrates economic and environmental data to provide a more comprehensive and multipurpose view of the interrelationships between the economy and the environment and the stocks and changes in stocks of environmental assets, as they bring benefits to humanity. Online e-learning courses are available, as well as an Implementation Guide and Diagnostic Tool, Technical Notes and Manuals.

MSP PROCESS	COST	FORMAT
Making the Case	Open-access	Downloadable file

Symphony

a method for ecosystem based maritime spatial planning, originally developed for Sweden but can be adapted to other countries. The model depicts through maps and other graphical representations (including sensitivity matrix), how ecosystem components respond to human pressures. The outputs inform planners of the baseline conditions and the potential effect of various planning options on the cumulative impacts in different areas, including incorporating climate change.

MSP PROCESS	COST	FORMAT
Planning	Open-access	Downloadable form

CASE STUDY:

Methodology is included in ongoing international collaboration with countries in the Western Indian Ocean through Swedish Agency Marine and Water Management's Program for Development Cooperation (SwAM Ocean 2019-2022).

Wealth Accounting and the Valuation of Ecosystem Services (WAVES)

a World Bank-led global partnership that aims to promote sustainable development by ensuring that natural resources are mainstreamed in development planning and national economic accounts. Under development is a toolkit for sustainable investment policy and regulation.

MSP PROCESS	COST	FORMAT
Making the Case, Review Enabling Conditions	Unknown	Unknown

Bayesian Belief Networks

directed graphs with probability tables, where the nodes represent relevant variable dependencies that can be continuous or discrete. BBNs can help define relevant spatial relationships. Typically, BBNs have been used in ecological studies or environmental management.

Leaflet

an open-source JavaScript library for mobile-friendly interactive maps.

TerraGo Toolbar

free plug-in for Adobe Reader that allows anyone to access, update and share GeoPDF maps and imagery. The combination of a geoPDF with the TerraGo toolbar allows for a portable, low-technology format that allows georeferenced comments, and is thus ideal for collating feedback from stakeholders (Agostini et al., 2010).assesses the potential cumulative impacts of maritime activities on the marine environment, and can be used for cumulative impact maps, sea use overlay analysis maps, and visualization of statistical results.

5 World Bank Data and Data Services

Data Development Hub (DDH)

The World Bank Development Data Hub is an important repository of information for project managers and TTLs as it provides access to over 4,000 public datasets, 15,000 indicators, and 200 visuals on a range of topics, as well as software tools for data use, curation, storage, sharing and reuse. This information can also guide managers on stakeholder engagement – helping to identify those stakeholders who are actively involved or gaps that need to be addressed in project implementation.

The selection of keywords is important in identifying relevant data sets without generating a lot of additional non-relevant datasets. For example, a recent search for the purpose of this chapter in the DDH was performed; 588 datasets were generated using the below keywords:

"marine, maritime, spatial planning, coastal zone management, coastal zone, oceanic, offshore, geospatial information, spatial data, blue economy, data model, coastal, MSP, ICZM, shipping, wind energy, coral reef, banks, fishing, energy, gas, oil."

The below table provides guidance to project managers and TTLs on the selection of keywords.

Table 2: Guidance on keywords for using the World Bank's DDH

	Guidance	Keyword examples
General	Keywords such as 'GIS' are likely to generate a lot of datasets	*marine, maritime, spatial planning, coastal zone management, coastal zone, oceanic, spatial data, MSP, ICZM*
Location	Data may not be available at the desired scale (e.g. local), however larger more regional datasets may be applicable. Keywords should start specific, and expand geographically if not available	*World, global, Latin America and the Caribbean, Cuba*
Sector	Where possible provide specifics on sectors you know are considered priority. Also consider removing keywords to help identify sectors that may not be considered priority, but are nonetheless present.	*wind energy, fishing, gas, oil, tourism*

Geospatial Operations Support Team (GOST)

The Geospatial Operations Support Team (GOST) helps to make the World Bank Group a sophisticated consumer of geospatial analytics works, and offers a variety of services to internal stakeholders, including technical assistance and purchasing support for data and imagery.

ITS Technology & Information Lab (ITSTI)

The ITSTI Lab serves as an internal technology advisor, and a knowledge and exploration hub around operationalizing emerging technologies for development impact, enabling WBG to be future-ready and competitive in the digital age.

Knowledge Information and Data Services (KIDS)

The KIDS Helpdesk supports the use of disruptive technology (particularly related to modern information and analytical aspects) in ENR GP operational and ASA activities. Its aim is to provide very quick inputs on requests and automate popular requests for the future.

6 Opportunity Areas for Engagement

Making the Case

Improved transboundary stakeholder dialogue would facilitate better data exchange and harmonization across nations and different sectors and would ultimately lead to an improved understanding of the issues at hand and the need for marine space management. A preliminary data gap analysis would also help identify which stakeholders need to be brought into the process from the early stages.

Increased access to consistent, comparable data and tools for ecosystem service valuation and mapping would provide important information to support the need for implementing MSPs. Knowledge products, databases, and technical guidance on methodologies would be useful to elevate the generation, acceptance, and use of this type of data.

Enabling Conditions

Accessing finance for long-term data management beyond project lives is not often considered in budgets but can facilitate a more sustainable, effective MSP.

Planning

Equitable, fair, and trustworthy relationships among all stakeholders facilitate good data-sharing practices that support decision-making. Marine spatial planning is extremely complex

and requires the communication and cooperation of a wide range of stakeholders with varying responsibilities, levels of technical understanding, priorities, and areas of interest.

Establishing data management protocols in planning can reduce challenges faced by unusable data.

These can include:

1. Data management protocols[7] (data management plans, data sharing protocols, documentation of recommended best practices, standards, experiences, examples, tools, software, etc.)
2. Incorporating long-term data management expenses into budgets (storage, personnel, training, technology, and software)
3. Incorporating long-term knowledge systems and data management plans into proposals and recommendations to governments and public administrations (Maragno et al., 2020)
4. Data management done in accordance with the above protocols can improve the quality, effectiveness, and long-term use of databases. The latter is an important aspect given the numerous project-based data portals in existence that are no longer usable due to the lack of long-term management.

Improved awareness and access to open-source or alternate data and tools can support planning decisions. Capacity building in clients to improve the identification, access to, and training in relevant tools and data can foster better decisions and long-term sustainability.

7 Data management protocols are meant to provide a guideline, best practices, and a standard procedure for receiving, managing, and using MSP-related data. Appendix B provides a brief overview of suggested protocols that could be adopted by projects. Protocols should be designed in a user-friendly, easy-to-use format to encourage uptake.

Implementation

Making use of existing data portals and aggregator sites is an important data management step in MSP monitoring and evaluation, as well as guiding future adjustments to the plan. The use of national and sub-national MSP data portals and GIS facilities is important for:

1. maintaining baseline and collected data during implementation
2. increasing transparency of the MSP implementation
3. displaying all up-to-date information to the wider public
4. providing a communication and analysis tool
5. encouraging stakeholders to contribute data

Existing databases and portals can be enhanced for use through improved harmonization and compatibility, opting for best quality data (over other similar data), improved organization and fragmentation of existing data sets, better availability, and lack of duplication (Quero García et al., 2020). For example, The European Marine Observation and Data Network (EMODnet) provides a common framework to aggregate and process marine data from diverse sources and generates a broad range of harmonized marine data, metadata, products, and services across the European sea basins (Quero García et al., 2020).

Identifying the status of national and international goals or targets can provide indicators for monitoring MSP implementation. These can include the Sustainable Development Goals (SDG), National Determined Contributions (NDC), post-2020 biodiversity targets, as well as other national sectoral goals.

Providing clients and implementers with an MSP 'Helpdesk', which offers technical support, guidance, and a communication system will also improve the usability of data and a more efficient data catalog.

Table 3 below summarizes the above as entry points during the MSP process.

Table 3: Entry points for good data management practices during the MSP Process

Making the Case	Review Enabling Conditions	Planning	Implementation
Transboundary, equitable stakeholder engagement Economic analyses	Financing for long-term data management	Equitable and fair stakeholder participation and data sharing Data management protocols Tools and data identification and sharing	Existing data portals and aggregator sites International and national goals and targets MSP Helpdesk and support

Supporting Institutions

In order to fulfill the potential for MSP, there must be awareness of and coordination with external bodies regarding standards and technical approaches (Beaujardière, 2016). The below table outlines some important institutions for MSP activities but is not considered comprehensive.

Institution	Description
Commonwealth Secretariat	The Commonwealth Secretariat has launched a public database full of practical training courses related to ocean action. Targeted at officials who work in the ocean sector, courses range from understanding blue carbon markets to aiding coral reef resilience to mainstream gender in ocean science.
European Marine Observation and Data Network (EMODnet)	EMODnet is a long-term marine data initiative, delivering harmonised transboundary marine spatial data for a number of relevant MSP data categories covering all European sea-basins. It offers a series of data portals: Bathymetry, Geology, Seabed Habitats, Chemistry, Biology, Physics, Human Activities and Coastal Mapping. Offers geospatial datasets.
European MSP Platform	The European MSP Platform is an information and communication gateway designed to offer support to all EU Member States in their efforts to implement Maritime Spatial Planning. It offers access to a team of experts, an interactive information gateway, question & answer service, and technical studies.
European Union	Has implemented the INSPIRE Directive – a legislation to create a European Union spatial data infrastructure for the purposes of EU environmental policies and policies or activities which may have an impact on the environment. The INSPIRE spatial themes are potentially useful for establishing coherence of spatial data across states, but do have limitations with respect to types of data included.
Earth Observation for Sustainable Development (EO4SD)	A European Space Agency initiative which aims to achieve a step increase in the uptake of satellite-based environmental information in the IFIs regional and global programs. It will follow a systematic, user driven approach in order to meet longer-term, strategic geospatial information needs in the individual developing countries, as well as international and regional development organizations.

Institution	Description
FutureMARES	Future Marine Ecosystem Services and Biodiversity is research project examining the relations between climate change, marine biodiversity and ecosystem services, focusing on effective restoration, effective conservation, and sustainable harvesting of marine resources. The goal is to provide science-based policy advice on how best to use NBS to protect future biodiversity and ecosystem services in a future climate.
Global Ocean Accounts Partnership (GOAP)	A diverse membership network with a common interest to ensure that the values and benefits of oceans are recognized and accounted for in decision-making social and economic development. The have developed a shared technical framework for ocean accounting, coupled with collaborative capacity-building activities that support the development, maintenance, and ongoing use in decision-making, of holistic ocean accounts that link together social, environmental and economic statistics. Have developed the Ocean Accounts Diagnostic Tool.
Geospatial Operations Support Team (GOST)	GOST works with geospatial data throughout the World Bank, and offering a variety of services to stakeholders, including advice on how geospatial data can help solve specific problems, purchasing support for data and imagery, and direct technical assistance for internal stakeholders, to help make the World Bank Group a sophisticated consumer of geospatial analytics, and ultimately carry out its development operations in the most cost-efficient and effective manner.
HELCOM	HELCOM (Baltic Marine Environment Protection Commission – Helsinki Commission) is A platform for environmental policy making at the regional level to protect the marine environment of the Baltic Sea from all sources of pollution through intergovernmental cooperation.
International Institute for Environment and Development (IIED)	An independent research organisation that aims to deliver positive change on a global scale, with a mission to build a fairer, more sustainable world, using evidence, action and influence, working in partnership with others. Has developed among other resources, toolkits such as No Hidden Catch: Mainstreaming Values of Small-Scale Fisheries in National Accounts, and Fair Fishing: Supporting Inclusive Fishing Reform in Fisheries
Intergovernmental Panel on Climate Change (IPCC)	The objective of the IPCC is to provide governments at all levels with scientific information that they can use to develop climate policies.
International Waters Learning Exchange & Resource Network	A content management system that supports knowledge sharing in the Global Environment Facility (GEF) International Waters portfolio. Includes resources such as the Marine Spatial Planning Toolkit
Marine Regions	Marine Regions is a standard list of marine georeferenced place names and areas. It integrates and serves geographic information from the VLIMAR Gazetteer and the MARBOUND database and proposes a standard of marine georeferenced locations, boundaries and regions. Offers geospatial datasets.
Marine Spatial Planning Global	Initiative coming out of UNESCO's Intergovernmental Oceanographic Commission (IOC-UNESCO) and the European Commission adopted in March 2017 a Joint Roadmap to accelerate Maritime/ Marine Spatial Planning processes worldwide. MSPglobal covers the following priority actions of the MSP Roadmap: 1) Transboundary MSP; 2) Sustainable Blue Economy; 3) Ecosystem-based MSP; and 4) Capacity building. On the other hand, the MSP Forum was implemented to achieve the priority action 5 on Building mutual understanding and communicating MSP.
Marine Life Information Network (MarLIN)	Provides information to support marine conservation, management and planning, based on available scientific evidence and designed for all stakeholders, from government agencies and industry to naturalists and the public. MarLIN hosts the largest review of the effects of human activities and natural events on marine species and habitats yet undertaken.
NASA Sea Level Change	Established to improve the understanding of regional relative sea-level change on a range of timescales. The web portal at was created to communicate the understanding that was obtained from these efforts and to provide an outlet for sharing data and guidance to the global public. Offers geospatial datasets, online mapping portal, interactive data visualization and simulation tool.

Institution	Description
Natural Capital Project	A partnership working to integrate the value nature provides to society into all major decisions. The ultimate objective is to improve the well-being of all people and nature by motivating greater and more targeted natural capital investments. They currently offer the InVEST suite of software.
Ocean+ Library	Connects users to the latest data and online resources on biodiversity at global and regional levels. The library is a consortium of various partners and offers users the change to submit data as well as download. Offers geospatial datasets.
Open Geospatial Consortium	The Open Geospatial Consortium is an international consortium of more than 500 businesses, government agencies, research organizations, and universities driven to make geospatial (location) information and services FAIR - Findable, Accessible, Interoperable, and Reusable.
Organization of Eastern Caribbean States	Implementers of the Caribbean Regional Oceanscape Project is a funded project by the Global Environment Facility through the World Bank which aims to move the Caribbean towards a blue economy. Project; not tool.
Partnership for Ecosystems for Disaster Risk Reduction and Resilience	Their Opportunity Mapping Tool is the first to offer a cross-mapping of ecosystem distributions and human exposure to hazards at a global scale. Specifically, the tool highlights geographic locations where ecosystem restoration or protection are particularly appropriate for reducing the impact of certain hazards. Offers online mapping portal.
The United Nations Geospatial	The United Nations Geospatial is a consortium that provides geospatial data, analysis and services for decision-making and operational support to the Security Council, the leadership of the Organization and its Secretariat services, including the United Nations Operations & Crisis Centre. The team is also augmented by geospatial experts in peace operations and their field missions, and supporting Regional Commissions and Offices Away from Headquarters. On request basis, the UN Geospatial services also supports and coordinates activities with the geospatial solutions and services of Agencies, Funds and Programmes. Offers maps and geoservices.
The Nature Conservancy	A global environmental non-profit working to create a world where people and nature can thrive. Has developed among others, the Caribbean Marine Maps and the Ocean Wealth Explorer, two useful mapping portals for MSP
United Nations Conference on Trade and Development (UNCTAD)	All statistics of UNCTAD are harmonized and integrated into UNCTADstat- free to use dissemination platform. It gives access to basic and derived indicators built upon common rules, harmonized environment and clear methodology supported by powerful data browsing system. UNCTADstat offers ready-to-use analytical groupings, with a unique coverage for countries and products and a particular focus on developing and transition economies.
United Nations Educational, Scientific and Cultural Organization	The Intergovernmental Oceanographic Commission of UNESCO is the United Nations body responsible for supporting global oceans science and services. Member states work together to strengthen our scientific understanding of the oceans for the benefit of humanity.
Unidata	Unidata is a diverse community of education and research institutions with the common goal of sharing geoscience data and the tools to access and visualize that data. For more than 30 years, Unidata has been providing data, software tools, and support to enhance Earth-system education and research.
United States Geological Survey	USGS is the sole science agency for the Department of the Interior, United States. It's mission is to monitor, analyze, and predict current and evolving dynamics of complex human and natural Earth-system interactions and to deliver actionable intelligence at scales and timeframes relevant to decision makers. Their data and imagery are the key foundation for Google Earth's 3D Timelapse Tool

Institution	Description
World Resources Institute	A global research organization whose vision is an equitable and prosperous planet driven by the wise management of natural resources; where the actions of government, business and communities combine to eliminate poverty and sustain the natural environment for all people.
World Meteorological Organization (WMO)	The WMO is dedicated to international cooperation and coordination on the state and behaviour of the Earth's atmosphere, its interaction with the land and oceans, the weather and climate it produces, and the resulting distribution of water resources.

7 Conclusion

Data is fundamental for any decision-making process, providing the ability to make informed choices and facilitating transparency between multi-stakeholder decisions. For the transboundary, multi-stakeholder MSP process, there are additional data challenges that are faced but are not insurmountable. There are also several tools available to aid in data collection, access to and analysis of data, and support using the data in a digestible format for stakeholders and decision-making. Tools are often developed for specific projects or purposes and so may not be as widely known by MSP project managers and planners. This chapter provided guidance on data needs for different MSP contexts and an overview of available tools. The nature of technology – including data and tools – and the rapidly developing world means that available data and tools will continuously grow past the date of this document. An online dashboard through the World Bank KIDS team has been created to support the continuity of this information beyond the life of this project.

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Appendix A
Marine data tools (infrastructures) that were actually being used by EU MSP Planners

Name	MSP Theme	Scope	Coverage
World Ocean Atlas	Describing marine area	Physics, Chemistry, Biology	Global
GEBCO	Describing marine area	Bathymetry	Global
EEA Database	Describing marine area Interactions in marine area	Physics, Chemistry, Biology Human activities	European
EMODnet Thematic Lots	Describing marine area Interactions in marine area	Physics, Chemistry, Biology Human activities	European
SeaDataNet	Describing marine area	Physics, Chemistry, Biology Bathymetry	European
European Atlas of the Sea	Describing marine area	Physics, Chemistry, Biology Human activities	European
Eurostat Database	Describing marine area	Economic value of human activities	European
ESPON 2013 Database	Describing marine area	Human activities	European
INSPIRE Geoportal	Describing marine area	Diverse	European
ICES Data Portal	Describing marine area	Physics, Chemistry, Biology	European
Copernicus MEMS	Describing marine area	Physics, Chemistry, Biology	European
SHOM Marine Data Portal	Describing marine area	Maritime boundaries and geophysical data, cables and pipelines, TSS	Global French maritime areas
Spanish Harbours Authority	Describing marine area	Physics	Atlantic, West Mediterranean Sea
Balearic Islands Coastal Observing and Forecasting System	Describing marine area	Physics	Atlantic, West Mediterranean Sea

Name	MSP Theme	Scope	Coverage
HELCOM Map and Data Service	Describing marine area Interactions in marine area	State of the biological, physical and chemical environment Distribution of human activities Sensitivities Pressures resulting from human activities Social value of human activities and the environment Economic value of human activities and the environment	Baltic Sea
Baltic Sea Bathymetry Database	Describing marine area	Bathymetry	Baltic Sea
SMHI Open Data Catalogue	Describing marine area	Physics	Baltic Sea
SEAGIS	Describing marine area	Diverse	Baltic Sea
GeoSea-Portal	Describing marine area	Physics, Chemistry, Biology Human Activities	Germany
Marine Data Infrastructure Germany	Describing marine area	Physics, Chemistry, Biology Human Activities	Germany
CONTIS	Describing marine area	Physics, Chemistry, Biology Human Activities	Germany
POSEIDON	Describing marine area	Physics	Greece
THAL-CHOR WebGIS	Describing marine area Interactions in marine area	Distribution of human activities Pressures resulting from human activities	Greece, Cyprus
Cyprus Coastal Ocean Forecasting Observing System	Describing marine area	Physics	Cyprus
SHAPE Adriatic Atlas	Describing marine area Interactions in marine area	Physics, Chemistry, Biology, Geology, Bathymetry Human activities	Adriatic Sea
ADRIPLAN Data Portal	Describing marine area Interactions in marine area	Physics, Chemistry, Biology, Geology, Bathymetry Human activities	Adriatic Sea
Flemish Banks Monitoring Network	Describing marine area	Physics	Belgium
Marine Atlas	Describing marine area Interactions in marine area	Physics, Chemistry, Biology, Geology, Bathymetry Human activities	Belgium

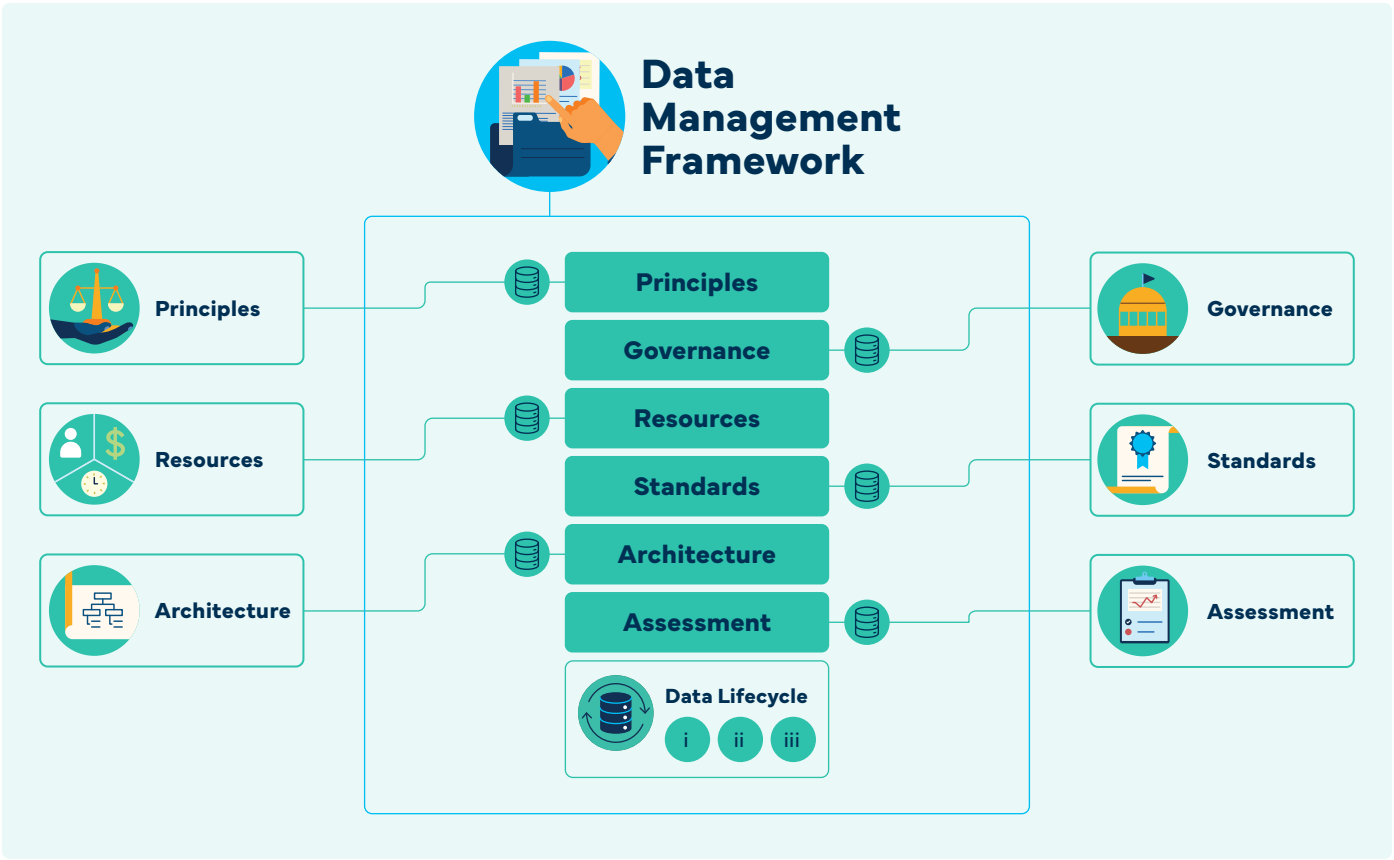
Name	MSP Theme	Scope	Coverage
Belgian Coastal Atlas	Describing marine area Interactions in marine area	Physics, Chemistry, Biology, Geology, Bathymetry Human activities	Belgium
Noordzeeloket	Describing marine area Interactions in marine area	Physics, Chemistry, Biology, Geology, Bathymetry Human activities	Netherlands
Marine Information House	Describing marine area	Physics, Chemistry, Biology	Netherlands
Marine Spatial Data Infrastructure	Describing marine area Interactions in marine area	Physics, Chemistry, Biology, Geology, Bathymetry Human activities	Denmark
MMO Marine Planning Evidence	Describing marine area Interactions in marine area	Physics, Chemistry, Biology, Geology, Bathymetry Human activities	UK

Source: European Commission, 2017

Appendix B
Data Management Framework and Protocols

These brief data management protocols are meant to provide a guideline, best practices, and a standard procedure for receiving, managing and using MSP related data (Maxam et al., 2019). The below information is pertinent to (i) internal data management as well as (ii) requirements or considerations that should be incorporated into projects.

This Environmental Data Management Framework defines and categorizes the policies, requirements, activities, and technical considerations relevant to the management of observational data and derived products and is based off protocols by the US National Oceanic and Atmospheric Administration (NOAA).



Principles

- Accessibility: e.g. data should be made fully and openly available to all users promptly, in a non-discriminatory manner, and free of charge (or at minimum cost)
- Long-Term Preservation: e.g. data should be managed as an asset and preserved for future use
- Information Quality: WBG data should be well documented and of known quality.
- Ease of Use: WBG observations should be transformed into relevant products for end users that are made discoverable and accessible online using interoperable services and standardized formats to encourage the broadest possible use

Governance

- The agency bodies that play a role in data management need to be clearly identified and organized into a hierarchy.
- Identify and/or develop policies and other documents relating to data management (e.g. "Data Documentation Procedural Directive", "External Data Usage Recommended Practice"); these can include internal WBG policies as well as relevant national, international or inter-agency ones
- Identify the formal authority and responsibility to enforce data management policy and directives

Resources

- Data cannot be adequately managed without proper resources, including personnel, budget and other supporting elements. Lack of resources is often a factor leading to data that are poorly documented, inaccessible, or improperly preserved (Beaujardière, 2016).
- Personnel should be informed of need for good data management principles. Relevant staff should be offered training in data management practices. Data-related knowledge of departing staff should be captured as part of exit procedures

- Budget is often used for data collection before data management, but needs to be prioritized as a line item in project development
- Other resources include Data Centers, pilot projects, teams, conferences, documentation, and software.

Standards

- Different types of standards are applicable in various phases of the Data Lifecycle. These include common vocabularies, standards for data quality, metadata standards that specify the content and structure of documentation about a dataset, data models and format standards that specify the content and structure of the digital data itself, and interface standards that specify how services are invoked.
- Adoption of common standards supports interoperability, which enables diverse data, tools, systems, and archives to be combined without writing custom software to handle every data link.
- The broad use of a small set of common data, metadata, and protocol standards across WBG, especially using international standards where possible, will decrease the cost of making and using WBG observations, enhance the utility of the data, and help avoid redundant technical development (Beaujardière, 2016).

Architecture

- Infrastructure: including the observing platforms and systems themselves, data collection and processing systems, the archival data centers and their associated systems for data ingest, storage and stewardship, dedicated data links such as the WMO Global Telecommunication System (GTS) and Satellite Broadcast Network (SBN), general-purpose network infrastructure, high-performance computing systems, and other computing resources. These infrastructure components are expensive to acquire and maintain. Costs can be reduced over the long term by avoiding project-specific systems built from scratch. Instead, gradual adoption of commodity hardware and software, and the establishment

of enterprise systems that provide functionality for multiple projects or the entire agency, are preferable.

- Service-based approach: WBG environmental data must be available to users both inside and outside of WBG. It is more efficient to make a given dataset accessible from a single authoritative source than to have users download, maintain, and possibly redistribute multiple copies, because the timeliness and accuracy of duplicative collections becomes increasingly uncertain. WBG data and metadata should therefore be delivered through services -- that is, through web-based interfaces that can be invoked by software applications. These services can offer functions such as searching for data, retrieving a copy or a subset of data, visualizing data (e.g., producing a colored map or a time-series graph), or otherwise transforming data (e.g., converting to other formats or other coordinate systems). Rather than establishing vertically-integrated "stovepipes" that only provide services for specific users and customers, a shared-services architecture
- Flexibility: Innovations in IT and engineering are frequent and may offer significant benefits in cost or efficiency. WBG should strive for modular and flexible architectures for observing systems, data management systems, and IT infrastructure in order to allow emerging technologies to be readily implemented. Custom-built, vertically integrated systems guided by inflexible design methodologies should be avoided because they are difficult to modify and may lock WBG into old technologies or specific vendors

Assessments

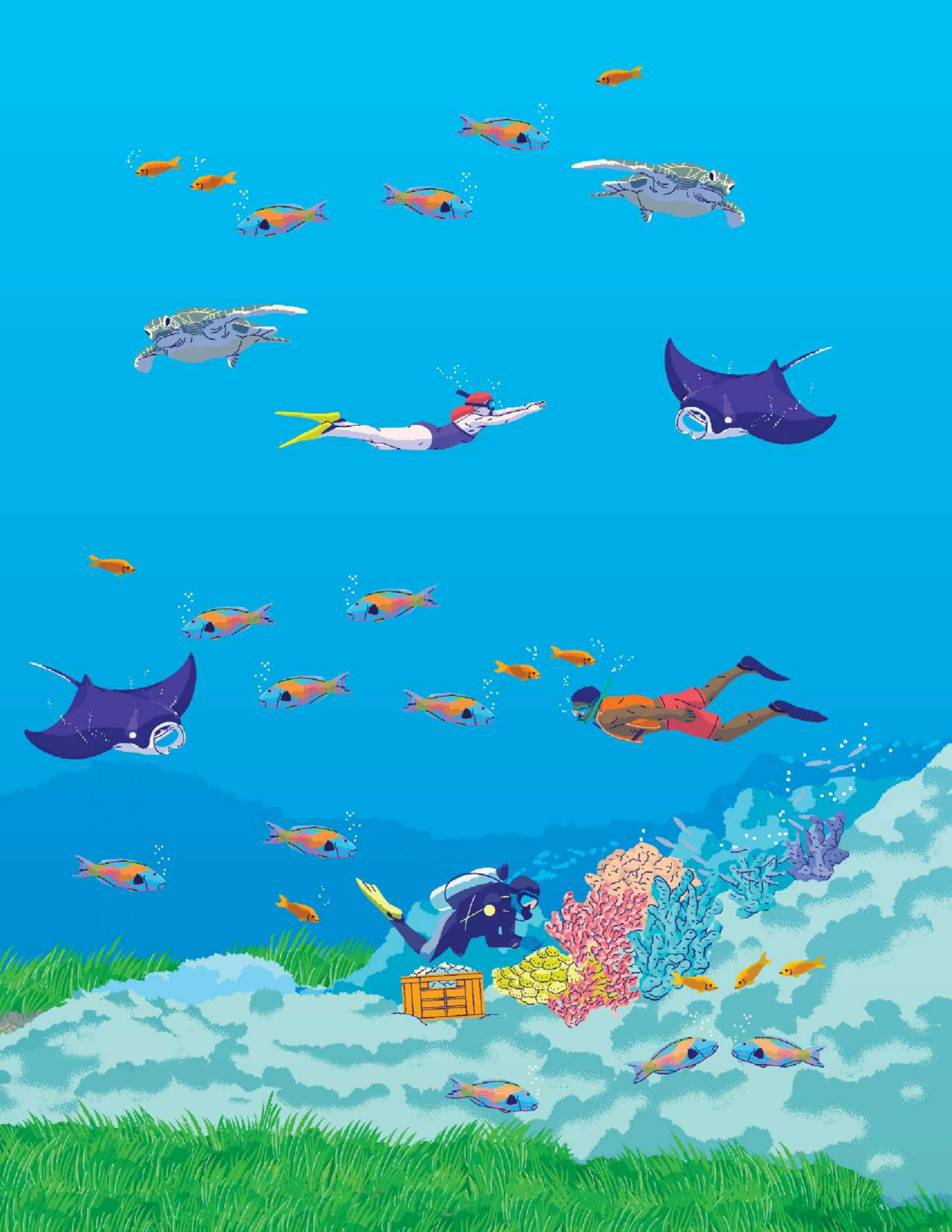
- Assessment of WBG data management activities includes estimating the current state, measuring progress, and getting feedback from users and implementers. The attributes we can assess include completeness of EDM planning, quality of metadata, level of data accessibility, and successful preservation for the long term.
- Estimating the current state of WBG EDM: The Technology,

Planning and Integration for Observation (TPIO) * program is assessing how data from WBG Observing Systems of Record are managed. This will provide a baseline status.

- Measuring progress: Line-office representatives report on the implementation of Procedural Directives at meetings of the EDMC. The EDMC chair reports progress to NOSC and CIO Council several times per year. TPIO and the NGDC Enterprise Data Systems Group have begun prototyping a Data Management Dashboard intended to show current values and trends in metrics such as metadata quality and data accessibility.
- Feedback: WBG personnel and contractors involved in EDM are invited to contact the EDMC and the DMIT regarding successes, failures, lessons learned and suggestions concerning this EDM Framework, EDMC Procedural Directives, and related activities. WBG data providers can seek and respond to feedback from users. The US Paperwork Reduction Act imposes some limitations on methods for gathering feedback

Data Lifecycle

1. Planning and Production: all activities leading up to data collection. E.g. defining, planning, deployment
2. Data Management: activities related to processing, verifying documenting, advertising, distributing and preserving.
3. Usage: all activities performed by the consumer of the data and are outside the control of the manager e.g. discovery, analysis, citation



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This publication is intended to support Bank staff and its clients involved in the MSP process.

PROBLUE is an umbrella multi-donor trust fund, administered by the World Bank, that supports the sustainable and integrated development of marine and coastal resources in healthy oceans.