Data collection and mapping- principles, processes and application in marine spatial planning

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Abstract

Marine spatial planning (MSP) is increasingly being used as a mechanism to manage the marine environment. Human activities can impact biophysical ecosystem features, reducing resilience and potentially impacting ecosystem services, which can affect the environmental, socio-economic and cultural benefits derived by coastal communities. Central to MSP is the collection and collation of baseline data on biophysical ecosystem features and ecosystem services to inform decision making and target management measures. The data collection process should be a structured, transparent process to ensure adequate data and metadata collation to enable it to be effectively used in MSP. This data should be subject to stakeholder consultation, producing quality assured information and mapping. The resources required to undertake data collection should not be underestimated. Recognition should be given to the limits of knowledge of the marine environment and its complexity. Planners and developers should exercise caution when using and interpreting the results of mapping outputs.

Highlights:

- Data collection and collection is integral to marine spatial planning and includes environmental, socio-economic and cultural data
- This paper highlights several necessary steps to ensure that data collection process is a structured and transparent process
- Data and mapping should be subject to stakeholder consultation to ensure accurate interpretation
- Data and mapping is likely to require significant investment of resources

Keywords:

Marine spatial planning, coastal zone management, data, stakeholder engagement, ecosystem approach, management, mapping

1. Introduction

As increasing demands are placed on marine ecosystems the effectiveness of the current sectoral approach to management has been brought into question [1,2]. The place based nature of ecosystems together with the temporal and spatial nature of human activities point towards a need to manage marine areas from a spatial and temporal perspective [3,4]. Marine spatial planning (MSP) is increasingly being recognised as an important tool for the sustainable management of marine ecosystems [5]. Whilst several definitions exist for MSP UNESCO defines it as ‘a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process’ [6]. MSP has been developed across the globe at a variety of spatial scales and administrative areas, from country-wide plans e.g. Scotland [7], Belgium, [8], Portugal [9]

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to regional or local plans e.g. Shetland Islands- UK [10], Dorset- UK [11], British Columbia- Canada [12].

A key component of ecosystem based management, and hence MSP, is to map biophysical conditions, and human uses of the ocean [3,13]. These human uses that are derived from the marine environment's ability to provide ecosystem goods and services can include both tangible and intangible benefits for sustaining and fulfilling human life [14]. The Millennium Ecosystem Assessment (MA) framework distinguishes four categories of ecosystem services: supporting services, provisioning services, regulating services, and cultural services [15].

The process of mapping requires the identification, collection and collation of available data on ecosystem services, as well as known significant biophysical elements or 'features' of the ecosystems from which these services are derived. Mapping can help to visualise competing demands and assess the implications of new uses or new management measures on both the environment and on existing users. It can be used to identify and test future sea use scenarios, helping to anticipate potential future opportunities, conflicts or compatibilities for the area and can guide proactive decision making [6].

The range of data available and its accuracy has the potential to influence how it is mapped, interpreted and subsequently used to develop spatial strategies within MSP. Ensuring the data collection processes is undertaken systematically and transparently, and understanding data limitations is an important consideration prior to mapping. Mapping is an important component of MSP, helping to inform management scenarios, and guide policy development. Understanding the limitations and resources required for these processes is important for marine planers, to help sure that adequate financial and human resources are in place to ensure that MSP aspirations can be met.

2. Data collection principles and processes in MSP

Scenario mapping and the development of marine spatial plans is not possible without the collection and collation of spatial data, herein termed 'data collection'. Given its importance to MSP it is important that collected data uses reflect, as far as possible, the current state and use of the marine environment. UNESCO [6] proposed a systematic process for the development of marine spatial plans, which could be considered similar to those undertaken in risk management.

Data collection and mapping is undertaken in parallel to policy development as part of the MSP process. A systematic seven step cyclical process is proposed, Fig.1, which complements the proposed UNESCO approach [6] to overarching MSP development. Stakeholder engagement is considered to be intrinsic to MSP [16] and should be initiated from the start of the process [17]. It is important that the views of all stakeholders are considered and that none are neglected or presumed [18], and can be considered important throughout all stages of the data gathering and mapping process.

<suggested place marker for Fig. 1>

2.1 Step 1 - Establishing the ecosystem context

Establishing the area that will fall within the governance of a marine spatial plan is likely to be an early procedural step of a plan's development [6]. However, the administrative boundaries of many plans will be smaller than the ecosystem area [19]. Marine features and activities may also be impacted by activities upstream (e.g. agricultural runoff) and downstream (e.g. open ocean) from the marine management area [6]. In addition, some ecosystem services may be gained in different spatial location to the ecosystem feature. For example, coastal tourism and recreation such as walking routes and shore-based wildlife watching may be reliant upon the marine ecosystem although they take place on the land. Therefore in some instances the landward and seaward extent of relevant data collection may be greater than the plan area [6]. Establishing the ecosystem context of the plan is likely to require stakeholder engagement to ensure that the area is sufficiently large to include all relevant components but not too large that the process overlaps excessively with other jurisdictions or is overly burdensome.

2.2 Step 2 - Identification of biophysical ecosystem features and services

The identification of biophysical ecosystem features and services allows the identification of the types of data and information that can support the MSP process. Stakeholder engagement can help to ensure that no biophysical features or services are excluded.

Whilst it is unlikely that all biophysical features of an ecosystem will be known, some species and habitats are considered more important than others in maintaining the function and resilience of marine ecosystems [3]. The Convention on Biological Biodiversity identifies seven criteria for ecological or biological significance, Table 1. In Europe legal protection is afforded to a range of environmental features through legislation such as the Habitats Directive, which focus on a variety of key habitats; especially those produced by structure-forming organisms, and the maintenance of adequate populations of apex predators [3]. Identification and the recording of known ecosystem components may include: coastal habitats, e.g. salt marshes and sand dunes; benthic species and habitats, e.g. reefs and beds; commercial species spawning areas; apex predators e.g. marine mammals, sharks and seabirds. The ecosystem services are likely to include socio-economic uses such as shipping, fisheries, aquaculture and tourism; and cultural services such as recreation, aesthetic and cultural heritage [6]. The relative importance of each will vary between regions.

<suggested place marker Table 1>

2.3 Step 3- Analysing and evaluating data

MSP requires a mix of spatial and non-spatial data on biological, physical, chemical, social, economic and cultural topics; which will require significant stakeholder engagement to identify available data and information [20]. Data on environmental conditions and socio-economic uses are regularly collected by a variety of government agencies, industry (companies, trade and governing bodies), charities, environmental groups and research institutes in response to a plethora of national and international obligations. Information on cultural uses such as locations of cultural heritage, tourist assets and recreational use may be collected by public bodies, businesses, sport governing bodies and clubs. Sea users are also a potentially important source of information [21].

Existing information on the marine environment is dominated by data on environmental conditions and socio-economic uses. It is likely that there will be less information on cultural ecosystem services

(CES) in a plan area. It is therefore likely that some new data collection will be required in plan areas. Where resources are limited, it is likely that data collection will have to be prioritised. This is likely to focus on areas where there is little data or where potential conflicts are thought to exist [20].

Existing data sets can be used in new analysis approaches, allowing maximum value to be extracted through 'reuse' or new interpretations [21]. New data collection can also be targeted to enhance existing data sets, reducing the level of new data collection required. Assessing existing data for accuracy is likely to be an important step in this process including, highlighting where data sets are inadequate and where there are data gaps.

New data collection and existing data sets will need to meet a range of quality assessment criteria including:

- Data ownership
- Collection granulation
- Collection purpose
- Quality and accuracy
- Non-spatial data and metadata
- Co-dependency / linkage
- Influence of outside actors

Data ownership:
Some data owners or knowledge holders may be more willing to share information if the data ownership resides with them and they have a level of control over how it is subsequently used and distributed. This may mean that it will be necessary to gain explicit written agreement as to whether the data can be made available to third parties and what format this could take (raw data, processed GIS, PDF/ paper copies only); for what purpose(s) the data can be used for; and whether permission to use a data should be time limited (e.g. 1 year, 5 years). The data collection process will therefore require consideration of data ownership, intellectual property rights and copyright.

Collection granulation:
The level of detail or granulation the data is collected to can influence its suitability for subsequent use but could also has the potential to affect stakeholder's willingness to share information. For example, fishermen may be willing to reveal the general location of important fishing areas but may be hesitant to share exact locations due to commercial sensitivity. However, if data is collected at too broad a scale it will be challenging to distinguish important areas, making it difficult at a project level for developers to avoid important features or uses.

Quality and accuracy:
Formal data confidence or quality assessments are increasingly being used prior to using data in marine plans and assessment (e.g. [22] and [23]). These assessments include a range of criteria including:

- Survey completeness- the completeness of the survey effort, presence of data gaps and how this influences the accuracy of the data
- Survey methodology- was the survey methodology suitable to collect the data suitable, and did it follow 'best practice' procedures

- Timeliness- when was the data collected, is the data still considered accurate and how frequently should the data be reviewed or updated to ensure it reflects current use
- Data collection accuracy- what level of granulation or spatial accuracy was the original data collected to
- Who collected the data, will this influence confidence in the data collected
- Was the data validated through an accredited process, expert or by a third party
- Should the data be ground-truthed or subject to further validation checks
- Should caveats be explicitly included identifying any limitations in the data quality, accuracy and extent

Collection Purpose:
Who collected the data and for what purpose has the potential to influence its suitability for re-use. Data sets may be collected under a number of assumptions or caveats that were considered acceptable for the purpose for which the data was collected, however this may render the data unsuitable for re-use (ethically and accuracy).

Non-spatial data and metadata:
Many data sets are likely to have non-spatial data and information associated with them. The collection and recording of this information, and its subsequent inclusion with the data set, can allow greater use and understanding, otherwise data may remain underused [6]. This non-spatial data can provide a range of information including temporal components that would be difficult to show in a static map. Data that could be gathered includes:
- Details of spatial and temporal use e.g. seasonal nesting areas for birds or fishing grounds
- Data collection methods, including who collected the data, and from whom (data source) and for what purpose

International data standards have been developed to ensure metadata is collected to a consistent standard, such as ISO and INSPIRE standards. Metadata is also normally gathered includes:
- Data contact- who should data users contact for further information e.g. government agency, trade body
- Copyright/ IPR information
- Scale accuracy
- Confidence levels
- Any additional metadata specific to the data type to conform to national and international standards

Co-dependency/ linkage:
The resilience of biophysical ecosystem features or services may be dependent on a number of different features or activities. For example a seal is dependent on both an area to forage and an area to haul out; fishermen may be dependent on a fishing ground and safe access to a port; and the enjoyment or use of a coast line for cultural purposes may be dependent on access as well as qualities such as aesthetic value and tranquillity.

A marine use or biophysical ecosystem features resilience could also be reliant on a number of different areas which offer the same resource. For example cetaceans normal rely upon more than one foraging area; fishermen may need to access a range of fishing grounds that are used in different weather condition or seasons. The reliance on one or more areas or factors could be termed 'co-dependence' or 'linkage', and where possible, should be included within associated information sets such as the attribute data or metadata, as well as data caveats and mapping outputs.

Influence of outside actors:
The distribution of an activity or feature may be influenced by outside actors, for example fisheries distribution could already be influenced by legislation and weather conditions [24]; cultural uses may have already been altered or eroded through unsympathetic development. It is important to understand how these factors have shaped current use as it may influence how they can adapt to new pressures. Information on outside actors and their influences should be gathered and collected as part of the data collection process.

2.4 Step 4- Evaluate future use of the marine environment through scenario mapping

Within the MSP process data can be used to evaluate current and future uses of the marine environment by identifying high value areas, assessing interaction between activities, assessing cumulative impacts or pressures, as a decision-support tool to assess development (both by the developer and planner) and investigate trade-offs [25]. There are now a number of decision-support tools available to marine planners and developers [26]. Decision-support tools are used to assess interactions, cumulative effects and to assist in the assessment of development proposals [26]. The information and data collected within the MSP process can also be used to plan future spatial use of the environment through spatial sea use scenario mapping and can guide proactive decision making, determining the future development of the plan area and in selecting the management measure needed to achieve the plans aims and objectives [6].

2.5 Step 5- Publish spatial data and mapping for consultation

The presentation format can affect how easily spatial information is understand both by users and by those with a management remit [27]. Publishing data and mapping in a variety of formats can influence data accessible, visualisation and allow for feedback and improvement [20]. Data presentation can include static paper format or electronic formats using mapping software such as GIS which can utilise both specialist software as well as free internet-based tools Public consultation may highlight ecosystem goods and services that were not identified through initial stakeholder engagement, will raise the profile of the plan data, help to refine or reconsider accuracy and increase buy-in.

How data is collected and then the subsequent cartographical methods employed to present the data has the potential to influence how information is used and interpreted [28]. This includes:

- The level of detail that the data is presented in (granulation)
- The presentation of the data as intensity or presence/ absence
- The use and choice of colour within mapping outputs
- Restrictions in the way the data are presented for example sensitive species locations may be buffered to hide the exact location of the feature

These factors may need be considered in conjunction with stakeholders to ensure that the data owner(s) / knowledge holder(s) are happy with the presentation method / mapping outputs and that the mapping methodology has not unintentionally introduced perceived bias or inaccuracy.

Some marine spatial plans have chosen to make their plan data and mapping outputs available to download in GIS format from a central point (e.g. in British Colombia and Shetland MSP [12, 23]. An alternative approach could require users to access data directly from the original data provider. The latter option offers the advantage that as the data owner/ originator updates or expands their data sets, users will be directed to their latest data sets. In addition if the data is inaccurate or found to include errors the responsibility would remain with the data owner. However, by not holding the data centrally, users will have to access data from multiple sources which could be time consuming. In addition the original data may not be available in as wide a range of formats as the marine spatial plan, potentially reducing access for some user groups.

2.6 Step 6- Plan Adoption

Once the marine spatial plan is adopted, monitoring and reviewing the use of the plan is normally initiated to help to determine how the plan and data is being used [6]. Monitoring of the use of spatial data can include how frequently it is requested or remotely accessed by users and how frequently data is cited in environmental impact assessments and other documentation [10].

2.7 Step 7- Review

On average marine spatial plans have a review period of 2-7 years [21]. The time frame for data review may be required to occur more frequently than the overall policy framework. Both the human uses and knowledge of the marine environment may change frequently and if the data within a plan is not regularly reviewed then the plan runs the risk of presenting misleading information, particularly if it is to be used to guide the siting of a new development. Some spatial plans have committed to updating known data sets outside of the review period [23].

3. Application of data in MSP

Within MSP spatial and non-spatial data are central to understanding our ecosystems and the goods and services they provide. As the policy framework of a marine spatial plan is developed it will be guided by the growing understanding of the marine environment and its uses, which places are most important to conserve and which places are compatible with development [6]. Policy development without considering all available baseline data, risks overlooking key ecosystem features and services which would lead to the failure of the plan to adopt the ecosystem approach to management.

Decision support tools can help to evaluate current and future uses of the marine environment. As identified in section 2.4, this normally includes identifying high value areas, assessing interaction between activities, assessing cumulative impacts or pressures, and tools to assess new development (both by the developer and planner) and investigate trade-offs.

3.1 Identification of high value areas and interactions

Mapping the spatial distribution of biophysical ecosystem features and services can help to identify areas which are currently providing the greatest environmental, socio-economic or cultural provisioning role. This can help in prioritising protection of these areas against pressures which could result in a loss of these services.

This information can also be used to assess interactions between activities (user-user conflict) and activities and the environment (user-environment conflict) [21]. Decision-support tools have been used in a number of marine spatial plans to show areas of relative constraint [29], relative importance [12] and areas of high sensitivity [30].

Spatial data and mapping can also be used to develop management strategies, including sectoral policy development and potentially establish zoning [26]. Zoning was utilised in the Belgium MSP [8] and sectoral specific guidance has been developed for the marine renewable energy industry in Scotland, to develop both national guidance [31] and regional guidance [29].

Biophysical features can also be considered of high value for reasons other than direct socio-economic or cultural benefit. As previously highlighted the Convention on Biological Biodiversity (CBB) gives criteria for defining biophysical significant areas, Table 1. The identification and protection of important biophysical features is an obligation for most countries under a range of national and international laws and conventions including those under the CBB. The identification of these areas can lead to the establishment of voluntary and statutory management measures, including the establishment of Marine Protected Areas (MPAs).

3.2 Assessing cumulative pressures on biophysical ecosystem features or on their services

Cumulative effects or impacts are the result of the combined effect of multiple activities over space and time [32]. Knowledge of existing marine activities and regulatory measures can be used to assess potential cumulative pressures on biophysical ecosystem features and services. There are a number of ways that human activities can interact resulting in: no cumulative impact, accumulative impacts, or fully additive impact; however most assessment tools can only consider additive interactions of human pressures [26].

Whilst most cumulative impact assessments have focused upon cumulative pressures on ecosystem biophysical features rather than on the ecosystem services, both can be impacted by multiple pressures. For example, cetaceans could be under pressure from marine noise and loss of foraging habitat due to development; fisheries could be under pressure from loss of grounds due to developments and conservation measures.

Decision-support tools can be used to identify the pressures that are currently being exerted on biophysical ecosystem features and services and to determine the potential additional pressures of further developments. Cumulative impact assessments have been undertaken on a range of scales, from global [33] to regional [34, 35, 36]. Examples of cumulative pressure assessment on socio-economic and cultural services are limited; however [37] identifies the need to record multiple and historic pressures that effect socio-economic activities such as fishing opportunity.

3.3 Guiding the siting of new marine developments and the assessment of impacts

Knowledge of existing high value biophysical ecosystem features and ecosystem services can help guide the placement of development. It can also help to assess likely spatial interactions between users, help to reduce potential conflicts and determine what mitigation measures should be implemented. A recent review of a regional marine spatial plan indicated that developers find the provisioning of spatial data useful in the site selection process [10], potentially reducing both user-user and user-environment conflicts.

The development of decision-support tools has the potential to assist decision-makers by allowing them to assess different development scenarios and to forecast the implications of development decisions, allowing more informed decision-making [26]. However, the confidence in these outputs will depend on quality of the baseline data and their ability to understand and predict complex interactions.

4. Problems with mapping

Our incomplete understanding of the marine environment can be manifested in data sets which do not fully reflect all spatial and temportal elements of the uses and values associated with marine features. Data sets may be out of date or may not detail the effects of competition or co-dependency of outside actors [24, 38]. Whilst data and mapping outputs can offer a useful baseline for further investigation it is important that the data’s limitations and accuracy are fully recognised before it is used as a decision-support tool in the MSP process or by third parties. In some cases data sets may only be suitable as baseline information and should not replace marine planner's or user's obligation to consult with stakeholders or preclude the need to collect new or more detailed data.

An example of this complexity is examined by [24], who examine the drivers causing fisheries utilisation. Changes in fishing patterns can be linked to regulation including spatial and non-spatial measures such as catch limits, rolling closures, zoning and MPAs [37]. They could also be linked to technological changes or advancements. The socio-economic benefits derived from fisheries locations at sea will be linked to an onshore community [24]. Whilst efforts can be made to map activities such as fishing grounds through participatory mapping, as external factors shape user choices data sets be subject to frequent temporal and spatial changes.

Biophysical ecosystem features may also show temporal and spatial fluctuations caused by user-environment impacts, climate change and natural fluctuations (e.g. [39]). Historical records can be used as a baseline to guide further surveying [40].

Due to the complexity of the marine environment and temporal fluctuations it is unlikely that our understanding of the marine environment will ever be complete, regardless of the level of resource allocated to data collection, mapping and modelling. This incomplete understanding may limit the potential detail of future planning. Where data sets are limited strategic decision making will be limited to high level decision making. At a regional level it may be easier to collect more detailed data to provide fine scale guidance, however it is perhaps unrealistic and unnecessary for this level of detail to be collected at a national level.

Where our knowledge or understanding of some uses is stronger than others, mapping outputs have the potential to create or reinforce bias towards certain types of use. Where there are significant data gaps and / or the data is out of date then the confidence of any mapping output is reduced. Projecting an incomplete understanding of the complexity of ecosystems and services into a 2-D map requires a number of assumptions and simplifications [38]. Robust strategies for dealing with complexity are therefore especially import for marine planners [3].

Inadequacies in the mapping process have the potential to further exclude certain groups or types of use from the MSP process. This may be of particular relevance to cultural ecosystem services which can be under-represented in mapping [24]. Therefore, whilst mapping can be an important tool for the management of the marine environment care should be taken in its use as a decision-support tool.

Whilst traditional views of mapping have assumed the process to be robust, several authors have argued this is not the case (see [41]). The mapping process has the potential to both create reality as well as to represent it [38]. Consideration should therefore be given to conscious and unconscious decisions made in a maps creation [41]).

5. Resource Implications

The process of identifying biophysical ecosystem features and the services that are derived from them has significant resource implications, in initial data collection and assessment, mapping, hosting and maintenance of data sets. The data collection process can be the most time consuming element of MSP [6]. Failure to allocate sufficient resource has the potential to undermine the MSP process by inadequately identifying all ecosystem services, inadequately incorporating all stakeholder views and providing data of a low accuracy. Recent examples of national plans and regional plans have utilised between 100 and 200 data sources [42, 12, 23].

Whilst typical policy cycles for review are every 2-7 years [21] uses of the marine environment have the potential to alter over this time frame, with new uses or changes to existing use. As spatial data becomes out of date there is the potential for it to misinform marine ecosystem assessments and the siting of developments.

In the UK it has estimated that to provide spatial data for MSP it will cost approximately £10,000 per region [43]. This however, seems inconsistent with the scale of the mapping exercise that has been undertaken within marine regions across the globe. Whilst information does exist that can be used in MSP this data will have to be collated from numerous sources, subject to a validation process, and data gaps identified. Where data gaps exist efforts will need to be made to collect new data. This is of particular relevance to cultural ecosystem services, which are likely to have the fewest number of associated data sets.

Failure to adequately consider all uses of the marine environment has the potential to isolate particular user groups, fail to address potential conflicts, lead to the degradation of the marine environment and to misdirect development. Whilst data collection is an integral part of marine spatial planning, it may not be feasible or desirable to delay starting MSP until all data is collected [6].

MSP is a continuous activity and will to generate information at various points in time. As greater knowledge of the marine environment is gained, scenario mapping can be updated and polices refined to reflect this changing level of knowledge i.e., MSP should include adaptive management [6].

6. Conclusions

The identification and mapping of marine and coastal features and services, incorporating data on environmental, cultural and socio-economic uses and values is a key component of MSP. Stakeholder engagement and consultation can help to identify information on the spatial extents of biophysical ecosystem features and services, producing quality assured data which can be used as a baseline within the marine planning process. Baseline data can help decision makers understand the benefits or ecosystem services currently being derived from the marine environment. The collection of non-spatial data and metadata allows qualities that may be difficult to represent in a map format to be included with data sets e.g. temporal variability. This additional data can allow for the assessment of the data quality and also allow for multiple uses of the data sets.

Development can impact biophysical ecosystem features, reducing resilience and potentially impacting ecosystem goods and services, reducing the socio-economic and cultural benefits derived by coastal communities. Decision-support tools can help marine planners to understand these impacts and can be used in the implementation of management measures in the marine consenting process and in planning future use of the marine environment.

It is likely that marine planners will need to exercise caution when undertaking and interpreting the outputs of mapping processes. Recognition will need to be given to the limits of our knowledge of the marine environment and its complexity when making policy decisions. The resources needed to undertake the data collection process should not be underestimated as it is likely that new data collection will be necessary to include all marine users in the MSP process.

Box 1:

Any new data collection should meet the same criteria as existing data sets. When planning the collection of new data, consideration should be given to:

- What are the resource implications for the new data collection?
- Can the new data be used to enhance existing data?

Where data will require participatory mapping consideration should be given to:

- Who will collect the data, and will this alter participation?
- Survey effort- how many respondents are needed to give the new data validity?

When analysing and evaluating existing and new data for inclusion and publication within a marine spatial plan consideration should be given to:

- Data ownership
- Collection granulation
- Collection purpose
- Quality and accuracy
- Metadata
- Co-dependency / linkage
- Influence of outside actors

Table 1. Convention of Biological Biodiversity Criteria for identifying ecologically or biologically significant marine areas. Source: Convention on Biodiversity, 2008.

Criteria	**Definition**	**Rationale**
Uniqueness or rarity	Areas containing either (i) unique (the only one of its kind), rare (occurs only in few locations) or endemic (unique to a particular geographic location) species, populations or communities, and/ or (ii) unique, rare or distinct habitats or ecosystems; and/or (iii) unique or unusual geomorphologic or oceanographic features.	These areas or species/populations are irreplaceable, and their loss would mean the probable permanent disappearance of diversity/a feature or reduction of the diversity.
Special importance for life history stages of species	Areas required for a population to survive and thrive.	Various biotic (living) and abiotic (non-living) conditions coupled with species-specific physiological constraints and preferences tend to make some parts of marine regions more suitable to particular life stages and functions than other parts.
Importance for threatened, endangered or	Areas (i) containing habitat(s) for the survival and recovery of endangered, threatened, declining species; or (ii)	To ensure the restoration and recovery of such species and habitats.

declining species and/or habitats	with significant assemblages of such species.	
Vulnerability, fragility, sensitivity or slow recovery	Areas containing a relatively high proportion of sensitive habitats, biotopes (small, uniform environments occupied by a community of organisms) or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.	The criteria indicate the degree of risk that will be incurred if human activities or natural events in the area or component cannot be managed effectively or are pursued at an unsustainable rate.
Biological productivity	Areas containing species, populations or communities with comparatively higher natural biological productivity.	Important role in increasing the growth rates of organisms and their capacity for reproduction, and providing surplus production to adjacent areas.
Biological diversity	Areas: (i) containing comparatively higher diversity of ecosystems, habitats, communities, or species, or (ii) with higher genetic diversity.	Important for evolution and maintaining the resilience of marine species and ecosystems.
Naturalness	Areas with a comparatively higher degree of naturalness as a result of the lack of, or low level of, human-induced disturbance or degradation.	Natural areas can be used as reference sites and will likely safeguard and enhance ecosystem resilience.

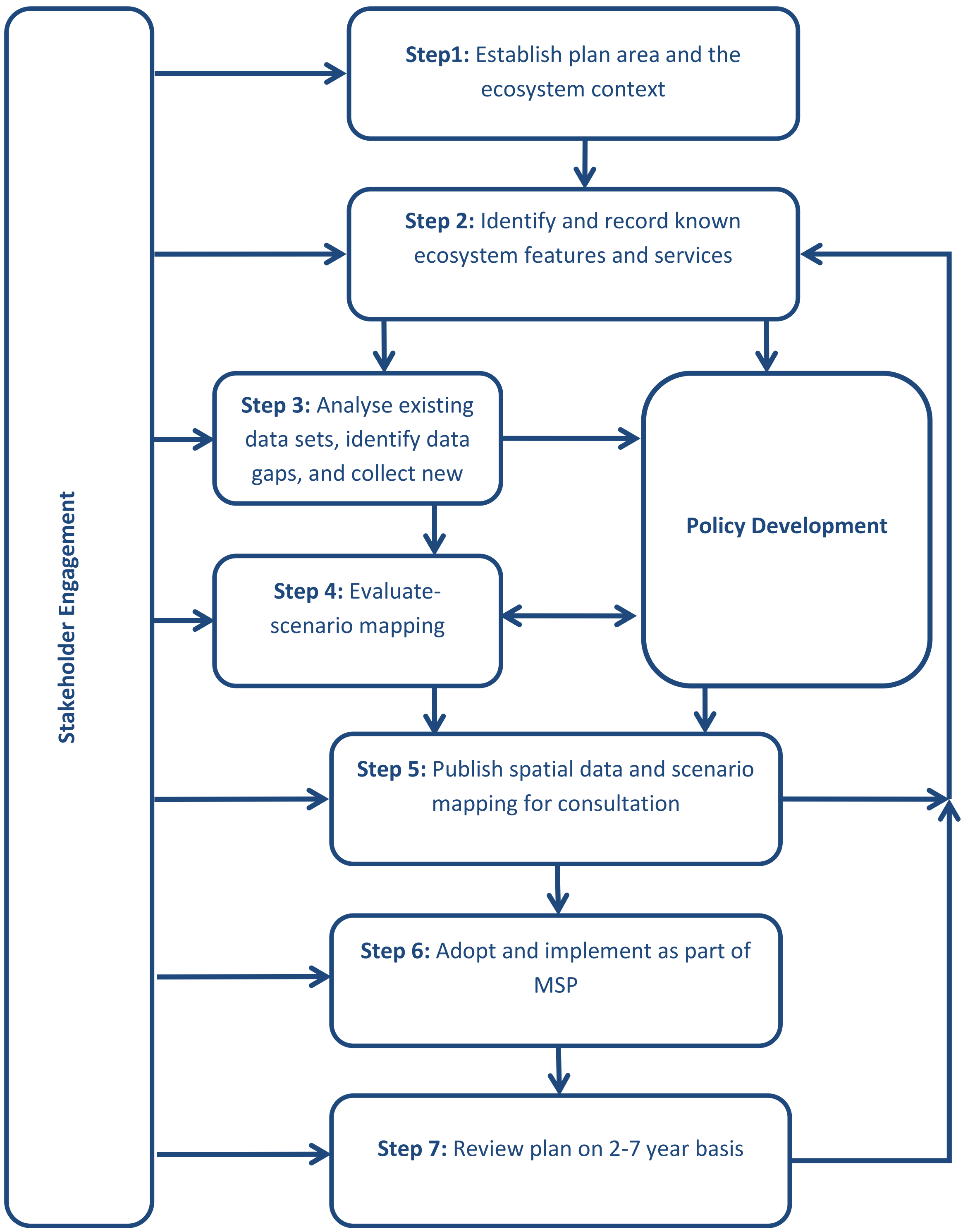

Fig.1. Steps in data collection and evaluation.

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