7.4. Applying ecosystem service mapping in marine areas

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Introduction

Accessibility and availability of spatially explicit information on marine ecosystem functions and ecosystem services (ES) are key components for successful marine management. As the uses and users of the marine environment increase in number and variety, there is a growing need for detailed Marine Spatial Planning (MSP), delineating spatial and temporal extents of different resource uses and the likely interactions of these uses, as well as impacts on the ecosystem and associated ES. In Europe, despite the new interest fostered by the Marine Spatial Planning Directive or the Biodiversity Strategy 2020, there are still very few initiatives for mapping marine ES at national or regional scales. Marine ecosystem service mapping is crucial for enabling sustainable marine resource use and is also equally important for ensuring successful marine protection through, for example, the designation of marine protected areas. In accordance with the EU legal framework for marine protection and planning of sea uses (Marine Strategy framework Directive and MSP Directive), MSP can enable the implementation of the ecosystem-based approach in management of human activities. This means that the collective pressure of human activities should be kept within levels compatible with the achievement of good environmental status and that the capacity of marine ecosystems to respond to human-induced changes is not compromised, while enabling the sustainable use of marine goods and services by present and future generations. Mapping can provide information on integrated sustainable development and conservation with positive outcomes for ecosystems as well as people.

Marine and coastal ES (MCES) mapping is still in its infancy (see Chapter 5.7.4) although several mapping studies have recently been undertaken. In most cases, these studies focus on mapping ES stocks and potential supply. However, in a few cases, it is has been attempted to associate marine ecosystems with the flow of benefits or the demand for them. This chapter explores the methods and data required to undertake a mapping exercise and how these vary depending upon the drivers of the mapping exercise, the scale of the study, the data available and the final use of the mapping by stakeholders.

Drivers of mapping

Mapping exercises may be driven by local communities (Box 1), local/regional policy and governance regimes (Box 2) or national/international policy (Box 3). The aim of ES mapping may simply be to understand and highlight current ES provision and to provide a baseline for future management strategies (Boxes 1 and 2), or an alternative aim may be to produce Marine Spatial Plans to enable trade-offs between different uses and users, ensuring the balanced and sustainable use of the coastal and marine environment for human benefit both nationally and across the world (Box 3). In deriving the approach to mapping, it is essential to maintain clarity in the drivers and aims of the exercise and to ensure regular communication with the end users to ensure the final product is both fit for purpose and readily understood. As such, it is recommended that the aim and methods are clearly defined from the outset with expectations managed accordingly.

Scale of mapping

Mapping exercises can vary in scale from local (Box 2) to regional (Box 1) to national (Box 3). In some cases, a mapping exercise may be designed to explore a single ecosystem service whereas others may explore a host of ES (Box 2 and 3). The scope of the ES analysis will influence methods and data requirements. Thus, the objectives, scale and constraints of the analysis should be clearly defined at the outset. ES mapping on a larger scale may yield results of greater uncertainty than mapping on a smaller scale. Thus, when deciding the scale of the mapping exercise, the end-user should be aware of this trade-off.

Data availability

In some cases, existing data may be sufficient for a particular mapping exercise (Box 2); however, in other cases, new data (Box 1) or a combination of primary and secondary data (Box 3) may be necessary. In data-limited contexts, practitioners often use habitat type as a proxy for ES supply (Boxes 2 and 3), especially in the case of regulating services. There is however a high level of uncertainty associated with this approach and innovative methods for modelling ES are becoming more common. Surveys tend to be used to access additional information on provisioning and cultural services (Boxes 1 and 3). If surveys are undertaken, it is advisable that approaches which are used are participatory, emphasising the design and implementation by community members who are also resource-users.

Data gaps and uncertainty

The lack of empirical assessment of ES and their supporting habitats and attributes, remains a key challenge. Low resolution habitat data continues to be an issue at all levels, generating generalised service provision maps at best (Box 3). The use of uncertain underlying information reduces the confidence in mapped outputs. As such, the communication of uncertainty and confidence is important in mapping ES (Chapter 6.3), to aid interpretation of the outputs by end-users (Box 2) and to ensure decisions are made with the full knowledge of potential uncertainty in the underlying data.

Stakeholder engagement

Stakeholder engagement is essential for successful marine ES mapping, from defining the aim and parameters of the exercise, to providing data, context, ownership and validation. As explored in Box 1, the combination of a participatory approach along with the mapping approach of provisioning and cultural ES allows for novel, informative and management-relevant maps of flow of benefits that help communities, especially those in collaborative management settings. To ensure stakeholders are engaged effectively, it is important to establish a two way dialogue throughout the process.

Conclusions

Under the present regulatory frameworks and the pressure to foster sustainable Blue Growth, it is crucial to undertake more accurate, policy-driven mapping of marine ecosystems and their services. Competing uses of marine resources should be analysed from a holistic perspective. ES maps should reveal the supply and demand of essential services across sectors and scales and should be co-developed and validated through iterative engagement with decision-makers, key stakeholders and the general public. A combination of methods is required to carry out MCES mapping, ranging from participatory mapping, stakeholder surveys, field measurements, to models. Care should be taken to ensure that the mapping exercise is well-defined at the outset with the aims, scope and scale agreed upon and the methods developed accordingly. The use of proxies and models can help to fill the data gaps until primary data can be attained, but uncertainty associated with such data tends to be high. Key recommendations should include the following:

- Be fully aware of the reasons for the mapping exercise and active encouragement of stakeholder engagement at the start of the mapping process, including the use of local champions, to ensure that: i) the ES mapping is designed to meet stakeholder, policy-maker and practitioner needs; ii) the best available data is collected; iii) the outputs are usable; iv) stakeholders can take ownership of the outputs.
- Clearly define the scale of mapping at the outset and design the approach accordingly.
- Collect and share more spatially-explicit data, ideally including low resolution data and with higher confidence levels. Data availability is still a limiting factor at all stages of marine ES assessments, from our understanding of the ecosystems and how they provide the ES, to the final social benefits and location of demand. Therefore national policy is recommended to actively promote the research on marine ecosystems in order to obtain more credible data on distribution of ES.
- Improve accessibility to modelled information which is often highly technical.
- Find ways of measuring and communicating uncertainty to stakeholders and end-users, as this is likely to be a significant factor in all marine ES mapping.

Box 1. From reef to table: Seafood security from community fisheries, Main Hawaiian Islands.

A small Hawaiian community was interested in understanding the total biomass of their fisheries as well as the community dependency on the ecosystem as a food source in order to promote better local sustainable fishing practices and community management initiatives. Methods included field expert surveys, participatory mapping and data quantification. The reason for mapping the seafood catch benefit from Kīholo Bay across the island was to understand how this bay feeds the rest of the island and the magnitude of the food provisioning ES it provides.

This study, involving collaboration between Conservation International, University of Hawaii and the community organisation, Hui Aloha Kīholo, mapped how seafood caught in Kīholo Bay travelled across the island and fed communities near and far. The location of people's fishing activities was not discretely mapped, as fishing ground locations remain local knowledge and confidential. The ES which was mapped was essentially the seafood benefit in equivalent number of meals which were generated and also exported from Kīholo Bay. The methods used included fishermen's surveys upon returning to shore and collecting data on species catch and size. Interviews with the fishermen revealed information on the end-users of the catch in order to assess the food miles (distance between the landing area and the place of consumption). The survey also investigated if catches were handled by the commercial sector or through non-commercial or not-for-profit activities. This single small-scale coastal fishery can provide more than 30,000 meals per year per square mile (2.6 km^2) and represents nearly $80,000 in landed value (Figure 1). Approximately 90 % of the catch is consumed at home or given away as part of cultural practice. These fisheries provide a significant source of food security and economic security. The results from this study are likely to be used by the community to propose local legislation that would ensure a sustainable local subsistence fishery.

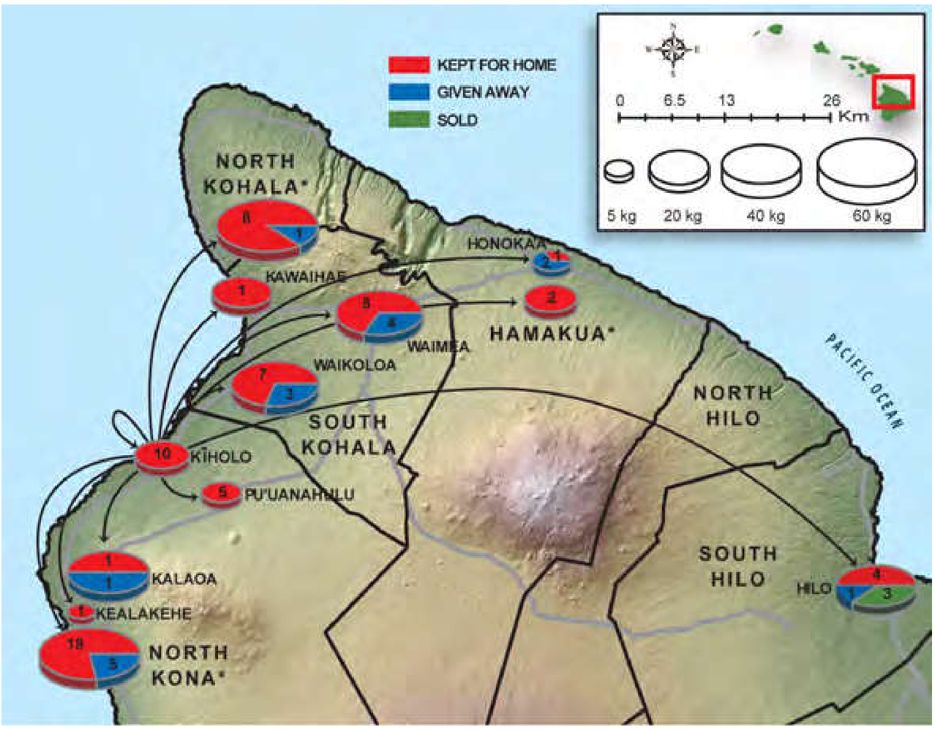

Figure 1. Mapping the transport of a small reef fishery harvest in Kīholo Bay, Hawiian Islands, from the land zone to place of consumption. Quantities (kg) are depicted by the size of the pie charts which also indicate the type of transaction.

Box 2. Mapping ES provision and associated uncertainty in the Plymouth Sound to Fowey region, UK

In the Plymouth Sound to Fowey region, UK, local marine managers requested maps of ES to enable understanding to be gained and communication about the current level of service provision, to provide a baseline against which future changes could be measured and to provide information for local policies and plans which include the Cornwall Maritime Strategy. This area comprises a range of marine habitats, supports diverse human uses and covers 934 km^2, extending 22 km offshore. A variety of ES were mapped including carbon sequestration, water purification, fish nursery habitat, nutrient cycling, pollution immobilisation and sea defence. The mapping exercise combined local knowledge, expert knowledge, habitat data and published literature, into a series of maps using ESRI ArcGIS v10.2. As empirical assessments of ES within the case study were lacking, the habitat type was used as a proxy for service delivery using published literature to determine these relationships. In most cases, this resulted in a three-point qualitative scale (low, medium, high) representing the level of each service provided by each habitat. The fish nursery service was, however, considered in terms of the number of commercially important species utilising the habitat in their early life stages. A confidence scale was also provided for each service, based on the quality and quantity of the available data. Habitat data from a number of sources was used to produce habitat maps. These maps were then combined with the ES data and confidence information, allowing the mapping of the level of service provision and confidence for each service.

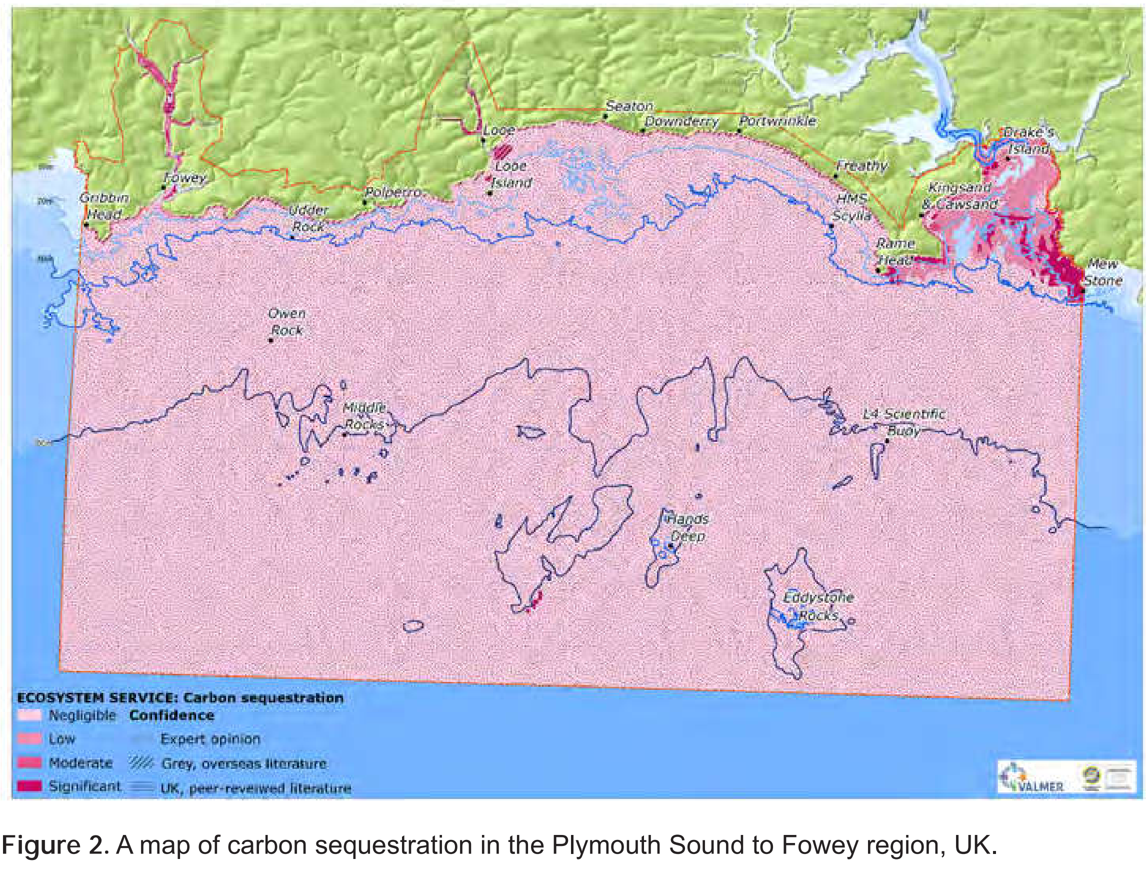

Figure 2. A map of carbon sequestration in the Plymouth Sound to Fowey region, UK.

Box 3. Maritime Spatial Planning (MSP) for the Latvian territorial waters and the Exclusive Economic Zone

Marine ES were mapped as an input for the Latvian national MSP. Areas significant for supply of provisioning, regulating and cultural services were mapped to avoid their deterioration when allocating space for new developments in the sea. Depending on data availability, different methodological approaches were used. Empirical assessments and spatial data on ES supply were available only for two provisioning services – wild animals and plants, including the catch of commercially important fish species (sprat, herring, cod, flounder) and red algae beds. The areas important for the fishery were mapped using data from fishery logbooks and visualised by calculation of the total value of fish catch and fishing acts within grid cells with a spatial resolution of 2.8 × 3 km^2. The area covered by red algae beds was calculated as a percentage of area unit based on actual field data from benthic habitat surveys. The potential supply of regulating services was mapped using benthic habitat data, expert judgement and indicators from literature. The habitat distribution map was used as a proxy for ES supply, including regulation of eutrophication processes, accumulation of pollutants in sediments, filtration by mussels, maintenance of nursery habitats and carbon storage. The ES distribution was presented in both individual maps and a summary map (Figure 3). The supply of a cultural service (tourism and recreation) was mapped using data on recreational options and their accessibility.

The maps were a useful tool in assessing possible impacts of alternative development scenarios and deciding on optimum locations of new uses - offshore wind farms and marine aquaculture farms. The main limitation of the mapping approach was a lack of empirical survey data on habitat distribution, resulting in a low certainty level of the maps on regulating ES.

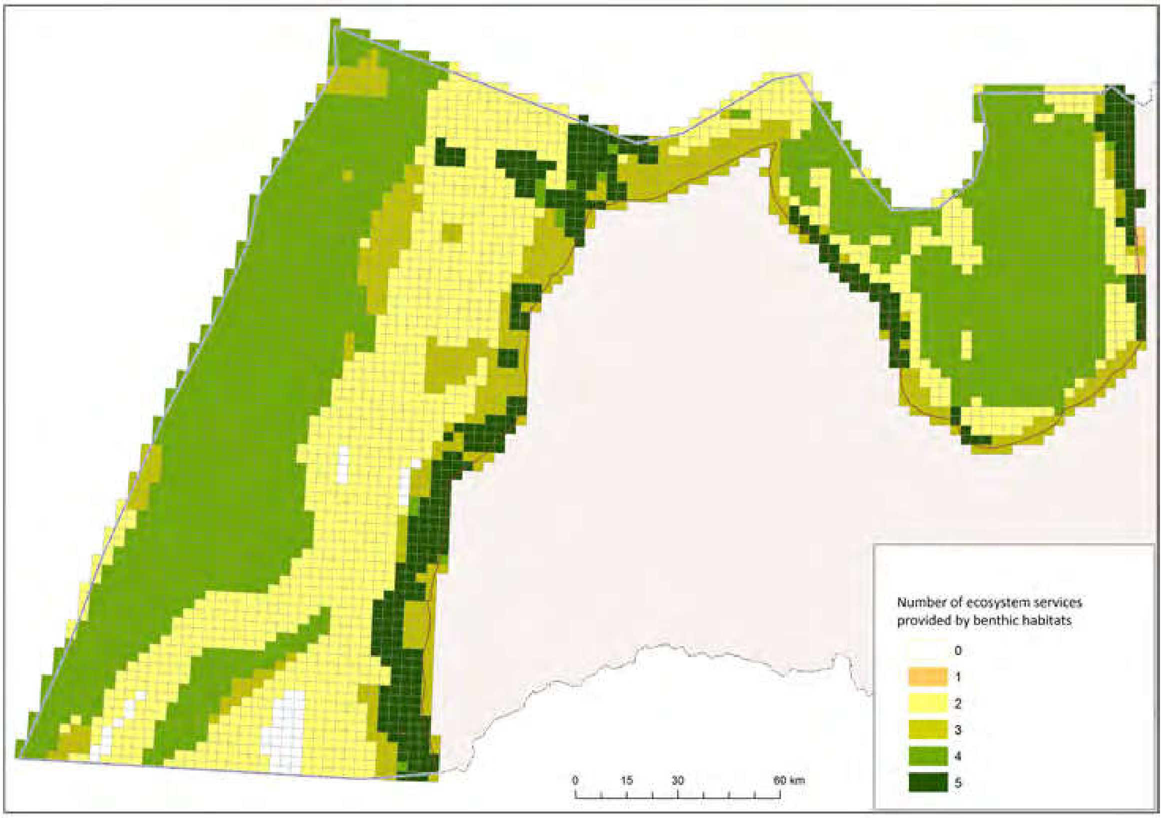

Figure 3. Diversity of benthic habitat-related ES in Latvian marine waters. Legend 0-5 indicates the sum of services identified within each grid cell.

Further reading

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