frontiers | Frontiers in Marine Science

TYPE Original Research
PUBLISHED 15 October 2024
DOI 10.3389/fmars.2024.1358950

OPEN ACCESS

EDITED BY
Vitor H. Paiva,
University of Coimbra, Portugal

REVIEWED BY
Tomas Vega Fernandez,
Anton Dohrn Zoological Station Naples, Italy
Helena Calado,
University of the Azores, Portugal
Jo Wilson,
New South Wales Environmental Protection Authority, Australia

*CORRESPONDENCE
Javier García-Sanabria
javier.sanabria@uca.es

RECEIVED 20 December 2023
ACCEPTED 09 September 2024
PUBLISHED 15 October 2024

CITATION
Pegorelli C, De Andres M, García-Onetti J, Rayo S and García-Sanabria J (2024) Marine protected areas as socio-economic systems: a method for defining socio-economic criteria in marine planning.
Front. Mar. Sci. 11:1358950.
doi: 10.3389/fmars.2024.1358950

Marine protected areas as socio-economic systems: a method for defining socio-economic criteria in marine planning

Camila Pegorelli[1], Maria De Andres[1], Javier García-Onetti[1,2], Silvia Rayo[3] and Javier García-Sanabria[1,2*]

[1]Department of History, Geography, and Philosophy, Integrated Coastal Zone Management Research Group, University of Cadíz, Cadíz, Spain, [2]University Research Institute for Sustainable Social Development (INDESS), University of Cadíz, Cadíz, Spain, [3]Faculty of Marine and Environmental Science, University of Cadíz, Cadíz, Spain

This research aims to define socio-economic criteria for prioritizing proposals related to new marine protected areas, boundary adjustments, area relocations, and network corridors within marine management approaches. The study also focuses on identifying ecosystem services (ES) that address the social dimensions of various spatial management approaches in the marine realm. The presented method quantifies nature's significance to human communities through stakeholder perceptions, bridging the gap between human activities and ecosystem services. The research defines essential socio-economic criteria, identifies the corresponding ecosystem services, and assesses their societal values within the socio-ecological system of a specific area, thereby enhancing the effectiveness of marine management processes such as marine spatial planning and marine protected areas.

KEYWORDS

ecosystem services, ecosystem based management, ocean governance, marine spatial planning (MSP), stakeholder perception

1 Introduction

The pressures exerted by human coastal and maritime activities often combine into cumulative impacts on many marine ecosystems (Halpern et al., 2008, 2015). As Zupan et al. (2018) pointed out, marine protected areas (MPAs) represent the most common approach used to mitigate human impacts on marine ecosystems (Lubchenco et al., 2003; Lubchenco and Grorud-Colvert, 2015) and are being increasingly used worldwide for both conservation and fisheries management (Boonzaier and Pauly, 2016; Kriegl et al., 2021).

The protection afforded by MPAs can vary widely, from minimal protection to no-take reserves and they can provide significant conservation benefits, from which socio-economic benefits are derived (Zupan et al., 2018a; Driedger et al., 2023).

The establishment and effective management of MPAs are essential for balancing human activities with the preservation of ecosystem services (ES). By designating and protecting these areas, the long-term health of oceans is promoted, sustainable fisheries are supported, climate change impacts are mitigated, and numerous benefits to both nature and society are provided (EEA, 2015). As the global community recognizes the value of these protected zones, efforts to expand and strengthen MPAs continue to play a crucial role in marine conservation and the sustainable use of oceans and seas.

Reflecting a global commitment to marine conservation and sustainable development, international targets, such as the Aichi Biodiversity Targets and the Kunming-Montreal Global Biodiversity Framework and Sustainable Development Goals, aim to protect significant portions of marine areas and promote sustainable development of the ocean (Driedger et al., 2023; CBD, 2021). However, establishing MPAs often leads to conflicts due to divergent interests, values, perceptions, and objectives among individuals, groups, or institutions (Cánovas-Molina and García-Frapolli, 2020). In this sense, for an MPA to be effective, regulatory efforts must be accompanied by several enabling conditions, such as enforcement, monitoring of results, long-term political commitment, sustainable financing, community participation, and benefit-sharing (Grorud-Colvert et al., 2021). In practice, MPAs are widely mentioned in statutes and regional as well as national legislation (Sletten et al., 2021), but in many cases, they are not accompanied by sufficiently active or effective management (Grau-Tomás and García-Sanabria, 2023).

Over the last few decades, MPAs have been complemented with a range of additional tools. Relatively recently, the concept of marine spatial planning (MSP) emerged. MSP is defined as "a public process of analyzing 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" (Ehler and Douvere, 2009).

The relationship between MSP and MPAs is integral to effective ocean management, although it is not always explicitly recognized (Trouillet and Jay, 2021). MSP plays a crucial role in identifying and designating areas that are most suitable for protection based on conservation objectives. This is achieved through the use of data layers on ecologically important marine areas, which helps ensure that MPAs are located in regions where they will be most effective in conserving biodiversity (Vaughan and Agardy, 2020). Furthermore, MSP extends beyond formal MPAs by identifying high nature value areas, thereby enhancing nature conservation beyond formal MPAs (Vaughan and Agardy, 2020).

MSP provides an integrated planning framework that balances the needs of conservation with those of various human activities. By moving away from sectoral management approaches, MSP addresses multiple economic and ecological objectives while reducing conflicts among different uses of the marine environment (Agardy et al., 2011). This integrative approach is increasingly recognized as a vital process for the effective implementation of ecosystem-based management (EBM) in maritime spaces (Douvere, 2008; Ansong et al., 2017).

EBM aims to promote the recovery and conservation of marine biodiversity by considering different impacts of human activities on ecosystems (García-Sanabria et al., 2021). Within this framework, ES are essential for illustrating the fundamental role of natural ecosystems in sustaining human livelihoods (La Notte et al., 2017). ES provides valuable insights into how ecosystems support human well-being, making them a critical concept in the planning and management strategies of both MSP and EBM (de Andrés et al., 2023). Therefore, any successful marine conservation effort—whether it involves MPAs, MSP, or EBM—must account for human activities to ensure the sustainability of both the environment and the services it provides (Folke et al., 2005).

To effectively integrate human activities into marine conservation efforts, stakeholder participation (SP) is essential for capturing social preferences, which are key to developing public policies in environmental management and spatial planning (Reed et al., 2021). By incorporating SP into marine planning and management, these policies are more likely to reflect diverse perspectives and gain broader acceptance, leading to sustainable outcomes for both the environment and the communities that rely on it. Developing a social preference framework for ES based on individual preferences is particularly important for guiding such policies, whether in the context of MPAs, MSP, or other conservation efforts (Sy et al., 2022). This approach enhances decision-making processes, allowing us to better shape our relationship with nature (Salles and Figueres, 2013) and tailor specific policy measures (e.g., a new MPA) to increase their acceptance and effectiveness among the population.

The valuation of ES is essential for their integration into marine planning and management. Environmental economics, which often relies on monetization techniques like cost-benefit analysis, has limited applicability in practical decision-making due to its focus on economic incentives (Rey-Valette et al., 2017; Müller, 2001). In contrast, ecological economics offers a broader perspective by also addressing the social, cultural, and ethical dimensions of nature's value. This more comprehensive approach supports the effective implementation of MPA and MSP by aligning economic, ecological, and societal values, thereby enhancing the overall effectiveness of marine conservation strategies.

A number of studies on ES have expanded theoretical knowledge on the subject (Müller et al., 2010) and developed detailed classifications based on systems theory (Potschin et al., 2016; Santos-Martín et al., 2015). This research is crucial for understanding the relationships between ecosystems and the services they potentially provide. However, in many cases, the complexity of the models hampers their applicability in practice, particularly in decision-making by managers (Müller et al., 2020). For both MSP and MPA, identifying the services provided by different ecosystems guides future planning and zoning scenarios (Coleman et al., 2011). Thus, the identification of ES should include a participatory process to provide legitimacy to the outcomes and the future measures implemented in an area (Maund et al., 2020).

To facilitate effective decision-making, it is essential to foster values that motivate local communities to actively engage in

conservation actions, both individually and collectively. Incorporating stakeholder perceptions of ES is critical for assessing their recognition by local society and understanding their relative importance within a specific geographical context (Rey-Valette et al., 2017). This approach not only enhances the decision-making process but also equips decision-makers with valuable insights to anticipate potential conflicts (Cánovas-Molina and García-Frapolli, 2020) and provides them with robust data and arguments for informed trade-off assessments. Knowledge and awareness of services through perception surveys are strategic for the implementation of environmental policies, but research on this topic is limited (Rey-Valette et al., 2017). The existence of an ecosystem service depends on direct and indirect uses, potential demand, or the recognition of non-use value. All methods for ecosystem service valuation must address the fact that their contribution to social welfare is determined by demand and actual use, even if beneficiaries are not always aware of it.

Statement-based valuation quantifies or qualifies the importance of nature for people based on their stated views about the significance of nature and human-nature relationships. This valuation is primarily based on interviews, surveys, or group discussions (Termansen et al., 2022). The focus of the work is on instrumental and relational values. Instrumental values refer to living and non-living entities used to achieve human ends or satisfy human preferences. As means to an end, instrumental values are theoretically replaceable, though this is not always the case in practice. Relational values pertain to the value of desirable, meaningful, and often reciprocal relationships between humans and nature, which are frequently associated with particular landscapes, places, species, forests, etc., and among people through nature (Anderson et al., 2022).

To effectively guide marine planning and management, this study introduces a methodological framework designed to identify ES using well-defined socio-economic criteria, which are derived from already in place policies, agreements and international documents (see Section 2). This comprehensive approach integrates the valuation of ES, informed by stakeholder perceptions, into both MSP and MPA (see Section 2). By doing so, the framework not only enhances the effectiveness of marine planning and management proposals by maximizing ecological, economic, and social benefits but also provides a crucial common ground (ecosystem services) between these two approaches, MSP and MPA. The integration of ES offers a shared foundation that facilitates the alignment of MSP and MPA objectives, promoting a more cohesive and sustainable decision-making process.

2 Material and methods

The proposed framework is based on stakeholders' perceptions, which allows for the ranking of both relevant ES and socio-economic criteria (Figure 1). It aims to address the need for operational tools that integrate the perceptions of stakeholders and residents to aid spatial planning decisions. The methodology is also based on various European Union policies and international agreements (Table 1).

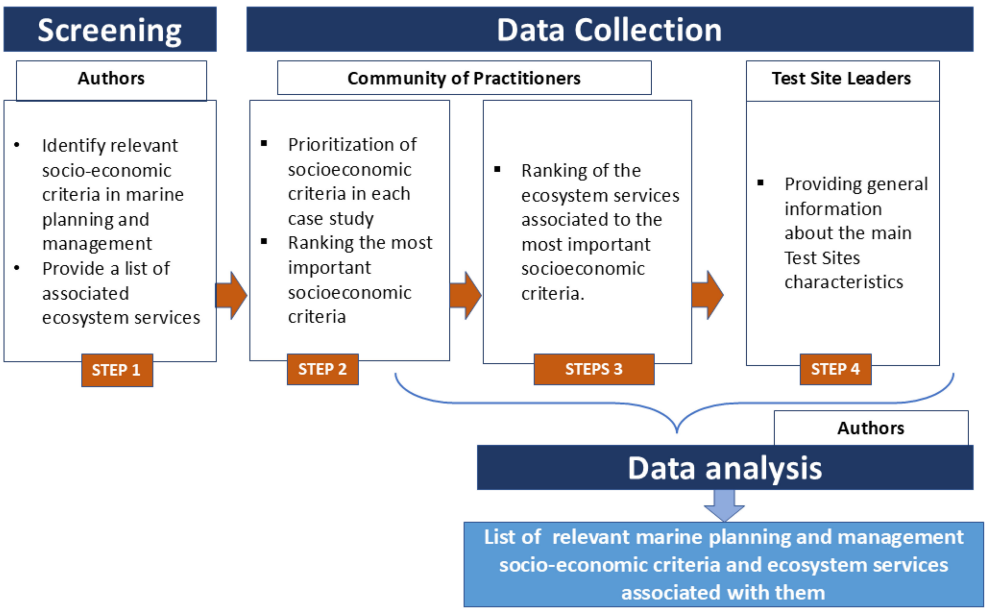

FIGURE 1
Overview of the methodology for identifying and ranking key socio-economic criteria and associated ecosystem services across the six test sites in the MSP4BIO project. The process is divided into four steps and data analysis. Test sites and their respective leaders are as follows: Cadiz Bay (University of Cadiz), North Sea (Flanders Marine Institute), Northwestern Mediterranean (National Research Council of Italy; Centre for Studies and Expertise on Risks, the Environment, Mobility, and Urban Planning), Black Sea [National Institute for Marine Research and Development "Grigore Antipa" and Centre for Coastal and Marine Studies (Bulgaria)], and Baltic Sea (Helcom and University of Tartu). The community of practitioners, composed of key stakeholders at each site, is chaired and organized by the test site leaders.

10.3389/fmars.2024.1358950

TABLE 1 List of codes, criteria, criteria description and related sources.

Code	Socio-economic criteria	Criteria description	Law and policy sources
SEC_1	Area is important for the generation of employment and income linked to no traditional activities	The area is (or can be) an important source of income and industrial jobs at industrial scale.< activities	WWF (2022a); WWF (2022b); WWF (2022c)
SEC_2	Area is important for fishery activity	The area is important for fishing, which occurs in that place or has the potential for it to occur. The area could also be important to the sector because it presents characteristics and conditions that sustain the fishery in another area. Eg: because it is a breeding and spawning zone.	WWF (2022a); WWF (2022b); WWF (2022c); European Union (2008); International Maritime Organization (2005); HELCOM (2012); UNEP (2017); Department for Environment, Food & Rural Affairs (2012); Cusack et al. (2008)
SEC_3	Area is important for the development of blue economy activities	The area has relevant characteristics that facilitate or support specific activities related to the blue economy (Aquaculture, offshore wind farm, biotechnology, tourism, …)	WWF (2021); WWF (2022a); WWF (2022b); WWF (2022c); Ehler (2014); EC-CINEA et al. (2022); European Union (2008)
SEC_4	Area is important for shipping	It is a place of great interest for the navigation, for example, because the area has relevant characteristics that facilitate or support it (sufficient depth, legal reserves), or in an indirect way because the area can support and regulate pressures like noise, discharges, etc	European Union (2008); European Union (1992); International Maritime Organization (2005); ACCOBAMS (2017); Miller and Christodoulou (2014); Dolch et al. (2013)
SEC_5	Area is important for dredging.	It is a place of interest (current or future) for activities related to dredging, both the extraction of sand (to increase the depth, for example) or the deposition of this dredged material.	Ehler (2014); UNEP/MAP-SPA/RAC (2020); Miller and Christodoulou (2014)
SEC_6	Area is important for locally-caught seafood	The specific activity of shell fishing occurs in that place or has great potential for it to take place there.	Ehler (2014); International Maritime Organization (2005)
SEC_7	Area has high scenic and/or aesthetic value.	It is a place where its landscape or aesthetic attractions stand out, or where the values associated with the area are culturally relevant (includes land-sea landscape, sea-land and submerged landscapes)	Ehler (2014); WWF (2021); International Maritime Organization (2005); UNESCO (2023); UNEP/MAP-SPA/RAC (2020)
SEC_8	The area is important due to the socio-cultural dependence of the coastal community with its environmental quality.	The use of living coastal and marine resources and their relationship with environmental quality is of particular importance regarding social, cultural, or local economic issues like fishing, recreation, tourism, and people's way of life and subsistence.	International Maritime Organization (2005)
SEC_9	Area is important for traditional human settlement, land-use, or sea-use which is representative of a culture, or human interaction with the environment.	Areas that preserve ancestral ways of life (in the use of resources, the activities they carry out, etc.), or settlements that are a sample of ancient cultures that inhabited the area.	UNESCO (2023); International Maritime Organization (2005); UNEP/MAP-SPA/RAC (2020)
SEC_10	Area is important because of the presence of cultural and tradition activities that support local food security and sovereignty.	The area is important due to the presence of activities (usually traditional or low intensity), such as fishing production or shell fishing, it is essential for the community to have a safe flow of food supply for own consumption and access to quality food	WWF (2021); Ehler (2014); International Maritime Organization (2005)
SEC_11	Area important for recreation and leisure.	The area is important for developing activities related to maritime and/or coastal associated with free time, such as sailing, diving, etc.	Ehler (2014); International Maritime Organization (2005); UNEP/MAP-SPA/RAC (2020); European Union (2008)
SEC_12	Area is important because of the presence of cultural symbolic value.	The area has a high value with respect to intangible cultural heritage, due to the existence of traditional activities or a culture that gives an ethnological value to the area.	WWF (2021); Ehler (2014); UNESCO-IOC/European Commission (2021); International Maritime Organization (2005); UNESCO (2023); United Nations Convention on the Law of the Sea (UNCLOS) (2023); UNEP/MAP-SPA/RAC (2020)
SEC_13	Area is important because of the presence of structure with significant historical and cultural (monuments, etc)	The area is of relevance for its tangible cultural heritage. There are relevant historical or archaeological sites, as well as coastal and marine	International Maritime Organization (2005); UNESCO (2023); WWF (2021)

(Continued)

TABLE 1 Continued

Code	Socio-economic criteria	Criteria description	Law and policy sources
		constructions or notable monuments for the local culture.	
SEC_14	Area is important for health of coastal residents and/or resource users (mental health, physical health, etc)	It is an important area for the well-being of the population that has an impact on their own health (mental health, physical health, etc…), either for the enjoyment of the area or its natural resources.	Ehler (2014)
SEC_15	Area is important with occurrence of iconic species/habitats for the local community.	It is an area with iconic coastal or marine species (seals, whales, an emblematic shorebird, etc.), or habitats highlighted by the local population (for example, a natural monument).	WWF (2022a); WWF (2022b); WWF (2022c); International Maritime Organization (2005); ACCOBAMS (2017); UNEP/MAP-SPA/RAC (2020); European Union (2008)
SEC_16	Area is important because allows the access to relevant areas for the marine users.	The marine area is a space to access another relevant area. For example, a maritime space that gives access to a fishing ground.	Authors expert criteria
SEC_17	Area is important to be managed due to spatial conflicts among users.	It is an area in which there are several current or potential uses and economic activities among which there may be conflicts of use for the same space or resources.	WWF (2021); WWF (2022a); WWF (2022b); WWF (2022c)
SEC_18	Area with current/potential importance to explore and demonstrate approaches and management solutions, and/or to scientific purposes	The area has outstanding natural and/or socio-economic characteristics to be used as pilot area for restoration actions, sustainable development of different activities, compensation mechanisms, green infrastructures, nature-based solutions, etc. And/or the area has a scientific interest.	International Maritime Organization (2005); UNEP/MAP-SPA/RAC (2020); European Union (2008)
SEC_19	Area is important for educational interest	It is an area in which environmental education activities are developed or can be developed, due to its natural characteristics.	International Maritime Organization (2005); UNEP/MAP-SPA/RAC (2020)
SEC_20	An area that has high scientific interest.	Area considered of interest to the scientific community, because research is carried out or can be carried out.	WWF (2021); Ehler (2014); International Maritime Organization (2005); UNEP/MAP-SPA/RAC (2020)

Observation: To enhance the clarity of graphical and tabular presentations in the subsequent sections, it should be noted that the term "CODE" refers to the unique identifiers correspond.

This research was conducted under the MSP4BIO project (www.msp4bio.eu), which provides information on six test sites located in five European sea basins. A perception analysis was conducted at each of these sites: Northwest Mediterranean, Gulf of Cadiz, Belgian North Sea, Western Black Sea, Baltic Sea Basin, and the Azores Archipelago.

2.1 Development of a methodology for the incorporation of socio-economic criteria in the marine planning and management process

The integration of socio-economic criteria into the creation and development of MSP in alignment with MPA is essential for harmonizing these processes across diverse European marine regions, each with its own policies and institutional frameworks. To achieve this, we leveraged existing socio-economic criteria from various directives, legislations, and international documents. The criteria list was initially derived from the from the report by Withouck et al. (2023), entitled *Summary report of existing criteria, species and habitat lists used in conservation and restoration initiatives. version 31/07/2023. Deliverable 2.2, MSP4BIO project*, which compiled around one thousand criteria relevant to socio-economic, environmental, and governance considerations. These criteria were systematically categorized and analyzed, providing a robust foundation for integrating socio-economic dimensions into marine planning and management. This approach aims to enhance the coherence and effectiveness of MPA proposals across different European marine contexts.

The first step is based on the list of socio-economic, environmental, and governance criteria identified by Task 2.2 and Task 4.3 of the MSP4BIO project. The original list included nearly one thousand criteria derived from relevant policies, directives, legislation, and international documents (Withouck et al., 2023).

To achieve this, socio-economic criteria relevant to marine planning and management framework were selected from the initial list. This process resulted in a final compilation of 20 socio-economic criteria (others criteria related to governance and biodiversity were not included in this analysis), which, while preserving the technical rigor of the original sources, have been refined for clarity and stakeholder engagement. Table 1 presents this curated list, offering a detailed overview of each criterion along with its corresponding source. This table serves as the foundational basis for the subsequent stages of the methodology. It is important to highlight that the definition of the term

10.3389/fmars.2024.1358950

TABLE 2 General information on ecosystems, human uses, and interview details at the test sites.

Region (test site leader)	Ecosystem	Activities	Scale	Interviewees (method)
Cadiz Bay (UCA)	**Habitats:** Meadows of three different seagrass species. **Importance:** Fish breeding and rearing, aquatic birds. Seafloor covered by seagrasses.	Industrial port operations, navigation, tourism, fishing, shellfish harvesting, aquaculture.	Local	8 (presential)
North Sea (VLIZ)	**Habitats:** Sandbanks, gravel beds, sand mason worm aggregations.	Sand and gravel extraction, dredging, dumping of dredged materials, shipping, aquaculture, defense, future offshore wind energy generation, and potential passive fishing.	National (Belgium)	5 (online meeting)
Northwestern Mediterranean (CNR/CEREMA)	**Habitat:** Productive pelagic environments. **Importance:** Two Ecologically or Biologically Important Marine Areas, two Important Marine Mammal Areas (IMMAs).	Shipping (one-third of Mediterranean traffic), exploring and demonstrating management solutions, scientific purposes, serves as a laboratory area for management practices.	International (Italy, France)	3 (online meeting)
Black Sea (NIMRD and CCMS)	**Habitats:** Sandbanks, coastal lagoons, large shallow inlets and bays, reefs, annual vegetation of drift lines, vegetated sea cliffs, submerged or partially submerged sea caves. **Importance:** Natura 2000 protected species (2 fish, 2 marine mammals), second largest bird migratory route in Europe.	Fishing, coastal/beach tourism, navigation/ marine traffic, military training, oil and gas extraction, nearby aquaculture.	National	3 (online meeting)
Baltic MPA (helcon and utartu)	**Habitats:** Vistula Lagoon, shallow brackish water area. **Importance:** Migratory and nesting water birds, brackish and sea fish species spawning area.	Land reclamation, watercourse modifications, coastal defense, seabed restructuring, non-renewable energy generation, fishing, transport, urban development, waste management, tourism, research, education.	International (Poland, Russia)	3 (online meeting)
Azores Archipelago (Graciosa Island) (UAc)	**Habitats:** Oceanic Island **Importance:** Hot spot of biodiversity, e.g., Deep black coral; other important species include Birds: Actitis macularius, Arenaria interpres, Bulweria bulwerii, Calidris alba, Calidris maritima, Calonectris borealis, Larus cachinnans, Larus fuscus, Larus hyperboreus, Larus marinus, Larus michahellis, Oceanodroma castro, Oceanodroma monteiroi, Onychoprion fuscatus, Puffinus baroli, Puffinus puffinus, Sterna dougallii, Sterna hirundo. Mammal: Physeter macrocephalus. Turtle: Chelonia mydas.	Limpet harvesting by artisanal fishermen.	Regional (Portugal)	1 (online meeting)
Total				**23**

This table includes the scale of the site (local, national, international), the number of interviewees, and the method of interview. Where UCA—University of Cadiz; VLIZ—Flanders Marine Institute; CNR—National Research Council of Italy; CEREMA—Centre for Studies and Expertise on Risks, the Environment, Mobility, and Urban Planning; NIMRD—National Institute for Marine Research and Development "Grigore Antipa"; CCMS—Centre for Coastal and Marine Studies (Bulgaria); UTARTU—University of Tartu; and UAc—University of Azores.

"blue economy" used in this work is the one established by the European Commission (2018), which states that "Blue economy refers to all economic activities related to oceans, seas, and coasts. It encompasses a wide range of interlinked established and emerging sectors." The blue economy sectors selected for exploring ecosystem services in this analysis were chosen based on their economic or cultural significance for the test sites, as identified through stakeholder feedback and existing data sources, including the work of Withouck et al. (2023)

To analyze the relationship between each socio-economic criterion and the associated ES, a team of four socio-ecological systems experts from the University of Cadiz conducted an initial assessment of potential correlations (see Table 2). The analysis utilized the Common Classification of Ecosystem Services (CICES) framework, established by the European Environmental Agency (EEA) for environmental accounting (Haines-Young and Potschin, 2018). Specifically, the study applied the "Group" level of the CICES 5.1 hierarchical structure (Section, Division, Group, Class) to link ES with

each criterion. This approach was chosen for its clarity, providing a concise list of ES that is accessible for stakeholder engagement. Furthermore, any ES not directly related to coastal and marine environments, such as those pertaining to livestock, was excluded from the analysis.

A selection of a current MPA was made for each test site leader. The selected MPA should be well-known to most members of the Community of Practitioners (CoP) involved in the case study at each test site. The CoP is composed of key stakeholders, including representatives from government, non-governmental organizations (NGOs), academia, research institutions, industry sectors (e.g., fisheries), consulting firms, MPA managers, MSP officers, and others relevant to the specific context of the test site. It is important to note that the composition of the CoP may vary among test site depending on the characteristics of each sea basin (local, national, and regional). Involving CoP members in this process ensures co-development and cross-validation of the materials produced, thereby enhancing the applicability and relevance of the outcomes.

To perform this task, the principle of Criteria Majority Judgment (MJ) was used. Based on the criteria list resulted from task 1 previously described, the respondents scored their opinions regarding the merit of each criterion on an ordinal scale defined as: "high priority," "priority," "neutral," "low priority," and "not a priority."

This exercise was designed to collect the opinions of the CoP members at each test site. The criteria should meet the following conditions:

- It helps to define or modify coastal and marine areas for the conservation of natural or cultural heritage;
- It allows for the allocation of uses and activities within the area where MSP or MPA is implemented (both for MSP and for MPA zoning);
- It supports conservation or other uses through the management of human uses and activities.

Once respondents had established the priority of criteria for their case study, they were asked to rank those criteria identified as either priority (P) or high priority (HP). In other words, the prioritization serves as a filter for selecting criteria specific to the test site. The ranking process involves respondents making valuation choices among these criteria, from the "most" to the "least" important.

Policy documents are increasingly addressing human well-being, which encompasses social, economic, governance, and health dimensions (Ban et al., 2019). However, integrating well-being with nature conservation remains relatively underdeveloped (Science for Environment Policy, 2018). Ecosystem services are crucial for bridging this gap, as they are fundamental to the well-being of individuals in various locations (McMichael et al., 2005). As highlighted in the introduction, recognizing the linkages between ES and the socio-economic criteria used in the designation and evaluation of MPAs and MSP can significantly enhance the decision-making process during negotiations, trade-offs, and stakeholder engagement efforts.

Therefore, this step focuses on identifying the existing relationships between socio-economic criteria and ES in each of the six case studies of the MSP4BIO project. With some adaptations to meet the needs of the MSP4Bio project, the perception analysis was based on the method "The Rapid Ecosystem Services Participatory Appraisal (RESPA)" developed by Rey-Valette et al. (2017) which was a method of valuing ecosystem services based on perception surveys. The work of Sy et al. (2022) on the valuation of ES and social choice is also considered.

Every criterion identified as either Priority or High Priority was then related to the associated ES. The CoP members ranked these ES according to their importance in their own MPA case study. Additional ES could be included if the CoP members deemed it appropriate, provided that these ES were based on those listed in the "group" column of the CICES.

The qualitative responses from the prioritization process were converted into a numerical format. Specifically, the responses were categorized into five levels: "High priority" (assigned a value of 4), "Priority" (3), "Neutral" (2), "Low priority" (1), and "Not a priority" (0). This transformation resulted in a numerical dataset that enabled the application of descriptive statistics and correlation analyses, facilitating the identification of trends and relationships within the data.

In the ranking process, only the top-ranked responses, such as those positioned first, second, and third, were considered for analysis. Responses ranked lower, including those positioned seventh or higher, were excluded. This exclusion allowed the analysis to focus on the most significant responses, thereby facilitating the identification of patterns and divergences among the higher-ranked items. Subsequently, the frequency of these high-ranking responses was examined to elucidate potential tendencies and trends.

To place the information obtained from each case study into context, the test site leaders were asked to provide basic information about the main characteristics (in terms of ecosystems and activities) in their working area (see Table 3). This approach allowed for the establishment of a correlation between the results obtained in the CoP and the features of the management area to which they refer.

The six test sites (Figure 2) reflect the diversity of geographical scales, i.e. local, national and regional seas, as well as socio-economic and environmental challenges in the selected European basins. These sites will be used to test the improved criteria for prioritizing additional protection areas, enhancing existing ones, and co-developing and testing a viable and effective management approach with local stakeholders. The knowledge generated from these test sites will address current needs and support ongoing local planning processes.

3 Results

In the case of the Baltic Sea test site, a distinct approach was adopted due to its large size. The Polish MPA was selected as the case study to represent the Baltic Sea. Consultations with other

10.3389/fmars.2024.1358950

TABLE 3 Average value of socio-economic criteria prioritization and respective standard deviation (SD).

Code	Average priority	SD
SEC_20	3,19	0,54
SEC_7	3,09	1,08
SEC_8	2,89	1,14
SEC_11	2,87	1,00
SEC_4	2,85	1,00
SEC_3	2,80	0,79
SEC_17	2,73	1,23
SEC_19	2,72	0,56
SEC_14	2,66	0,81
SEC_9	2,65	1,22
SEC_2	2,59	1,17
SEC_15	2,53	1,10
SEC_13	2,48	1,16
SEC_10	2,47	1,08
SEC_18	2,34	1,42
SEC_6	2,29	1,12
SEC_16	2,02	1,26
SEC_12	1,83	1,12
SEC_1	1,83	1,12
SEC_5	1,63	1,01

stakeholders but the CoP were conducted. Henceforth, this selected MPA will be referred to as the Baltic MPA.

3.1 Socio-economic criteria analysis

The CoP members of all case studies have given the highest priority to the following socio-economic criteria (Figures 3, 4; Table 4).

SEC_20. An area that has high scientific interest;

SEC_7. Area has high scenic and/or aesthetic value;

SEC_8. The area is important due to the socio-cultural dependence of the coastal community with its environmental quality;

SEC_11. Area important for recreation and leisure;

SEC_4. Area is important for shipping.

On the other hand, socio-economic criteria 5, *"Area is important for dredging,"* and 1, *"Area is important for the generation of employment and income linked to non-traditional activities,"* were given the lowest priority for all the study cases (Table 4).

When asked about ranking the socio-economic criteria (Supplementary Material 7), the CoP members of all case studies ranked the following six criteria as the most important:

SEC_3. *Area is important for the development of blue economy activities;*

SEC_5. *Area is important for dredging;*

SEC_6. *Area is important for locally-caught seafood;*

SEC_7. *Area has high scenic and/or aesthetic value;*

SEC_16. *Area is important because allows the access to relevant areas for the marine users.*

All the above criteria were ranked in the first position, with criterion SEC_3 being the most commonly ranked as the highest in importance, occurring 47% of the time among the CoP members of all case studies.

On the other hand, criterion SEC_9, "Area is important for traditional human settlement, land-use, or sea-use that is representative of a culture or human interaction with the environment," was ranked with the lowest importance. Criterion SEC_10, "Area is important because of the presence of cultural and traditional activities that support local food security and sovereignty," also received a low ranking overall: 54.6% of respondents ranked it in positions 12, 13, and 15, while 18.2% ranked it in the third position. Finally, criterion SEC_15, "Area is important due to the occurrence of iconic species or habitats for the local community," was ranked in the eleventh position by 26.7% of the respondents.

As shown in Figure 4, the prioritization of socio-economic criteria varies among case studies, indicating that local context is crucial when applying policies to European MPAs.

3.2 Linking and valuating socioeconomic criteria and ecosystem services

The linking between ecosystem services and criteria were performed by researchers of the University of Cadiz with background on ES. Table 2 presents the potential linkages between each criteria and the correspondent ES, having in mind that to perform this work the emphasis were given to the Column group of the CICES V5 to facilitate the work with stakeholders.

The CoP members across the five case studies ranked ES based on their importance to their respective MPAs.

In the Bay of Cádiz case study, ES rankings ranged from 1.33 to 3.49 (Figure 5, left image). Four ES received an average response percentage higher than 50% (Figure 5, right image), they are: *Providing habitats for wild plants and animals (nursery), pollination, and gamete dispersal*; *Utilizing the environment for sport, ecotourism, recreation, and health; Conserving elements of nature deemed essential for preservation; Facilitating research and study of nature.*

In the Mediterranean case study, ES rankings ranged from 1 to 4.5 (Figure 6, left image). Two ES had an average response percentage higher than 50% (Figure 6, right image), highlighting the importance of regulatory ES, as following: *Other types of regulation and maintenance services by abiotic/biotic processes; and Lifecycle maintenance, habitat, and gene pool protection.*

For the Black Sea case study, ES rankings ranged from 1.1 to 6 (Figure 7, left image). Four ES received an average response percentage higher than 50% (Figure 7, right image), emphasizing provisioning and regulatory ES, as following: *Other types of regulation and maintenance services by abiotic/biotic processes; Wild animals (terrestrial and aquatic) for nutrition, materials, or*

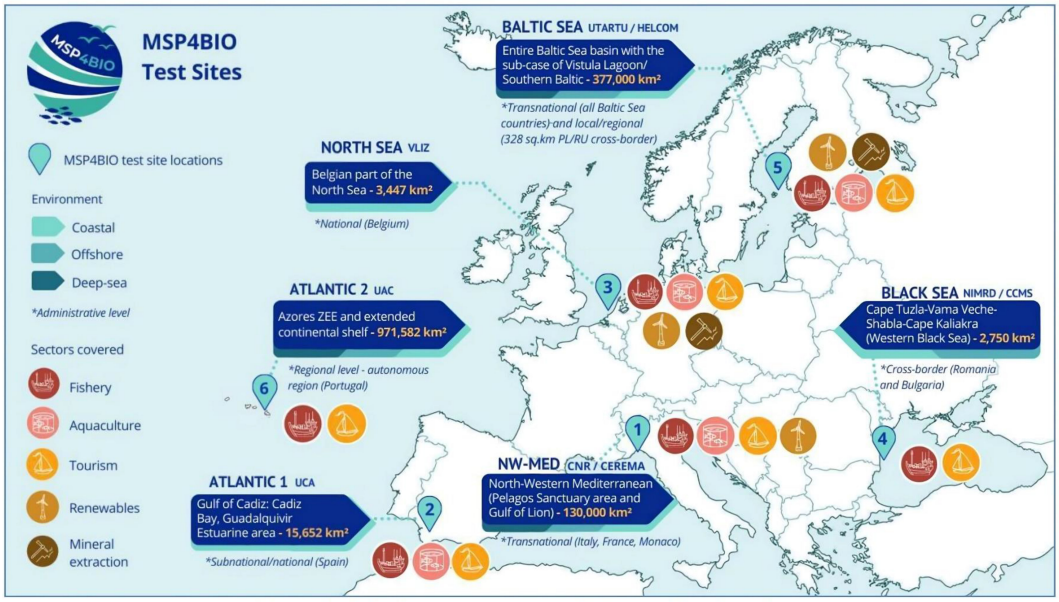

FIGURE 2
Test sites of MSP4BIO project. Where UCA, University of Cadiz; VLIZ, Flanders Marine Institute; CNR, National Research Council of Italy; CEREMA, Centre for Studies and Expertise on Risks, the Environment, Mobility, and Urban Planning; NIMRD, National Institute for Marine Research and Development "Grigore Antipa"; CCMS, Centre for Coastal and Marine Studies (Bulgaria); UTARTU, University of Tartu; and UAc, University of Azores. (Source: MSP4Bio Project, www.msp4bio.eu).

energy; Lifecycle maintenance, habitat, and gene pool protection; and Water used for nutrition, materials, or energy.

In the Azores case study, ES rankings ranged from 1.33 to 2.5 (Figure 8, left image). It is important to mention that this case study does not have a graph related to ES ranking with a response frequency greater than 50% due to the absence of more than one respondent. The top three ES, listed: Intellectual and representative interactions with the environment (abiotic and natural); Other

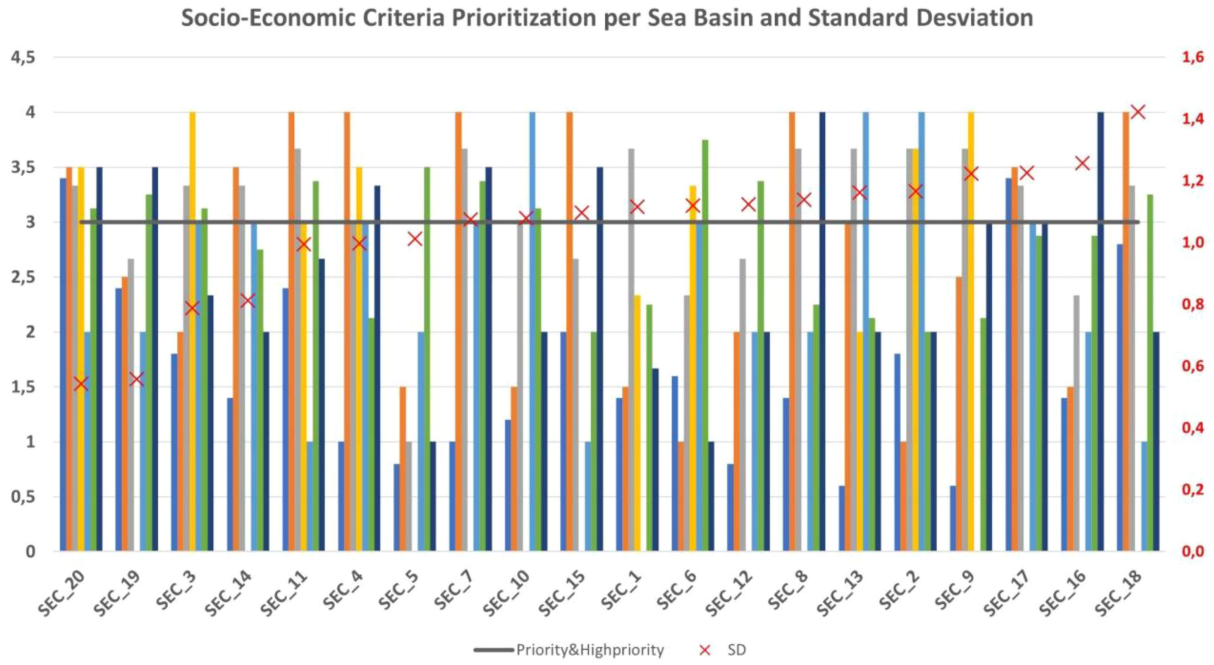

FIGURE 3
Average scores of socio-economic criteria prioritization in MSP4BIO test sites. Values higher than or equal to 3 indicate Priority and High Priority. Standard deviation (SD) is indicated with red crosses, corresponding to values shown along the vertical axis on the right. Color bars represent the case study sites: blue for the North Sea, yellow for the Baltic Sea, dark blue for the Azores, orange for the Mediterranean, light blue for the Baltic MPA, grey for the Black Sea, and green for Cadiz.

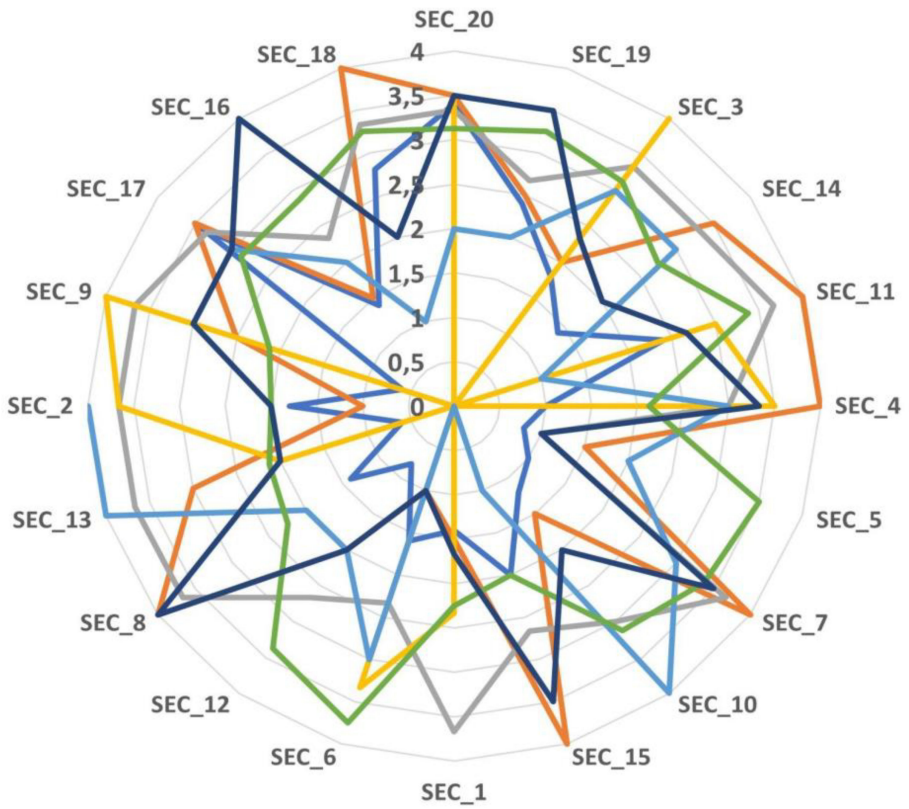

FIGURE 4
Average prioritization of socio-economic criteria per test site. Colors represent the case study sites: blue for the North Sea, yellow for the Baltic Sea, dark blue for the Azores, orange for the Mediterranean, light blue for the Baltic MPA, grey for the Black Sea, and green for Cadiz.

types of regulation and maintenance services by abiotic/biotic processes; and Physical and experiential interactions with the environment (abiotic, e.g., caves; natural, e.g., whales). More detailed results are available on the Supplementary Material.

In the North Sea case study, ES rankings ranged from 1.17 to 4.38 (Figure 8, right image). Only one ES, *"Navigation surface,"* was selected by more than 50% of participants, with a value of 1.2 and accepted by 60% of participants.

The results obtained by correlating ES with various socio-economic criteria are available in the Supplementary Material. These findings are derived from the responses provided by the different CoP established within the MSP4BIO project case studies. No responses were received for the Baltic Sea case study. The first column, "Criteria Related," corresponds to the potential relationships between ES and socio-economic criteria identified by the authors (Table 2).

The results demonstrate the unequal relationship between different ES and the socio-economic criteria that should guide marine management. In general, the provisioning service *"Wild animals (terrestrial and aquatic) for nutrition, materials, or energy"* stands out, as it exhibits a broad connection across all cases with various socio-economic criteria. Additionally, the regulation service *"Lifecycle maintenance, habitat, and gene pool protection"* is noteworthy. However, two cultural services, *"Intellectual and representative interactions with the environment (abiotic and natural)"* and *"Physical and experiential interactions with the ecosystem (e.g., caves; biota, e.g., whales),"* are notably associated with a greater number of socio-economic criteria. This holds true whether linked to research and knowledge, cultural identity of the inhabitants, sports and recreational functions, educational aspects, or health importance. This outcome reflects the significant role that protected marine areas play in shaping the socio-economic context of the localities where they are located.

4 Discussion

As a first step in valuing ES to support marine planning, it was necessary to establish a methodological framework for identifying socio-economic criteria. This framework provides a clear basis for prioritizing proposals such as new MPAs and revised MPA boundary reallocations. Integrated into the MSP process, it ensures a comprehensive approach to decision-making with an emphasis on EU legislation, building upon existing documents to facilitate future integration.

A list of 20 socio-economic criteria was compiled. While this list is robust, drawing from essential legislation, agreements, and documents relevant to all case studies, it remains preliminary and

10.3389/fmars.2024.1358950

TABLE 4 Socio-economic criteria ranking and frequency of answers.

Code	Ranking position	Frequency
SEC_1	2	36,4%
SEC_2	2	25,0%
SEC_3	1	46,7%
SEC_4	2	18,8%
SEC_5	1	22,2%
SEC_6	1	33,3%
SEC_7	1	28,6%
SEC_8	3	16,7%
SEC_9	17	25,0%
SEC_10	3, 12, 13 and 15	18,2%
SEC_11	2, 6 and 7	20,0%
SEC_12	2	26,7%
SEC_13	3	30,8%
SEC_14	8	23,1%
SEC_15	11	26,7%
SEC_16	1	25,0%
SEC_17	3	28,6%
SEC_18	4	30,8%
SEC_19	2 and 6	16,7%
SEC_20	2	33,3%

open to expansion based on proposals from the Community of Practice (CoP) and experts within each test site.

Interestingly, no new criteria proposals were received after the completion of the exercises. This absence of proposals could be attributed to two possible reasons. Firstly, it is plausible that the existing criteria comprehensively encompass all the diverse realities analyzed in this research. Alternatively, it may indicate the need for a targeted exercise specifically designed to analyze and propose new criteria, thereby enhancing the methodology. By explicitly including socio-economic criteria, the MPA plans recognize community use and governance of resources, maximize equity and access to traditional fishing grounds, and better support long-term food security and livelihoods of local communities (Mangubhai et al., 2015). Surprisingly, there are few examples of research focused on developing socio-economic criteria for marine management in the scientific literature. Apparently, scientific literature is more focused on socio-economic assessment tools (SPA/RAC–UN Environment/MAP, 2019; Rosales, 2018; Peters et al., 2023) to introduce such dimensions into the diagnosis of the areas to be managed.

In reference to the study objective of identifying ES and their societal value associated with MPAs, it is crucial to note that utilizing the ES provided by the Common International Classification of ES under the "Group" column has yielded positive outcomes. Expanding beyond the "Group" column would possibly result in a longer and more specific list of ES, making it more challenging to work with and potentially leading to misunderstandings, necessitating further explanations to stakeholders. Restricting the analysis to the "Group" column simplifies understanding for stakeholders while still enabling the derivation of pertinent conclusions. In this sense, it is also important to mention that the North Sea Test site has adjusted the different types of ES to make it easier for their CoP members to proceed through the exercise. This test site used the nomenclature by Custodio et al. (2022).

The correlation between ecosystem services (Table 2) and socio-economic criteria shows the intricate connections between ecological, economic, and cultural dimensions in marine planning and management. Provisioning services play a pivotal role in supporting economic activities such as fisheries and aquaculture, while cultural services are essential for preserving cultural heritage and fostering tourism. Regulation and maintenance services are critical for ensuring that human activities do not compromise environmental integrity. Additionally, the integration of socio-cultural dependence and scientific interest highlights the importance of a holistic approach that considers the full spectrum of ecosystem services. This comprehensive understanding enables the development of management strategies that not only prioritize ecological sustainability but also support economic growth and cultural preservation, ultimately leading to more effective marine conservation efforts.

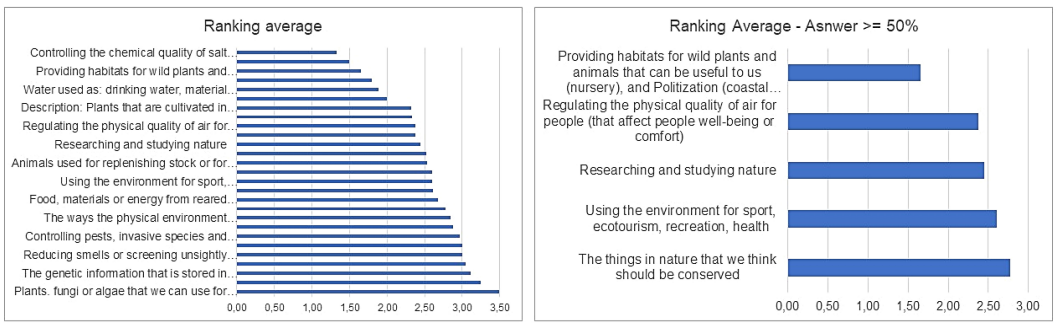

FIGURE 5
Bay of Cadiz. Left image: Ecosystem services ranking average. Right image: Ecosystem services ranking average from frequency higher than 50%.

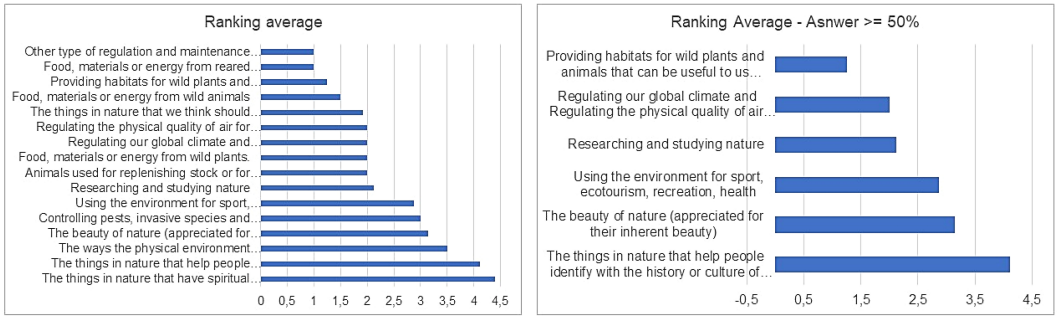

FIGURE 6
North-western Mediterranean. Left image: Ecosystem services ranking average. Right image: Ecosystem services ranking average from frequency higher than 50%.

When analyzing the results of the importance criteria versus ES for each test site (Supplementary Material), some interesting points stood out. For example, the analysis reveals significant regional variations in the prioritization of ES across different marine areas, with certain services such as genetic material from all biota and regulation of baseline flows consistently linked to socio-economic criteria in multiple regions. This consistency shows a tendency of their importance in marine planning and management. However, the observed variability in services like pest and disease control highlights the influence of regional ecological and socio-economic contexts, suggesting that tailored approaches are necessary to effectively integrate ES into marine planning and management. The concentration of diverse ES in regions like the Black Sea and Azores indicates the need for comprehensive management strategies, while the limited presence of certain services in areas like the North Sea reflects divergent regional priorities, emphasizing the importance of region-specific strategies to balance ecological sustainability with socio-economic development.

The ES scored with the highest social value were those regulatory services that sustain human well-being (Figures 5–8). The high importance attributed to regulatory services correlates with the attention given to them in the definition of a marine protected area, understood as "marine space designated and effectively managed to protect marine ecosystems, processes, habitats, and species, which can contribute to the restoration and replenishment of resources for social, economic, and cultural enrichment" (Reuchlin-Hugenholtz and McKenzie, 2015). According to this definition, an MPA must protect those natural elements that provide the capacity of the protected area to deliver regulatory ES. This natural foundation will enable the MPA to generate resources that local society uses for its well-being. In this regard, MPAs should emphasize the protection of the natural components of the socio-economic systems of which the marine area is a part (De Andrés et al., 2018; Rees et al., 2018; Barragán Muñoz et al., 2020; Marcos et al., 2021). This idea is important because, in the absence of societal activities and the pressures they introduce, protection would be pointless, hence the need to view MPAs as spaces that are part of a larger socio-economic systems (de Juan et al., 2023).

A second emerging issue is that cultural services provided by MPAs are equally or even more important than provisioning services (Figures 5, 6, 8, left image). This makes sense when considering that provisioning services often involve the extraction of resources from the system, except in cases where resources are used renewably. This can sometimes contradict the idea of protecting a marine area, so these categories of use are limited. Indeed, fisheries are often displaced by MPAs that usually support other activities deemed less impactful, to maintain the livelihoods of neighboring communities (Erskine et al., 2021).

In fact, in four of the five protected MPAs analyzed, stakeholders have highlighted the importance of the cultural services provided by their MPAs. In contrast, only a few provisioning ES have been rated as important in the studied MPAs (Figures 7, 8, right image).

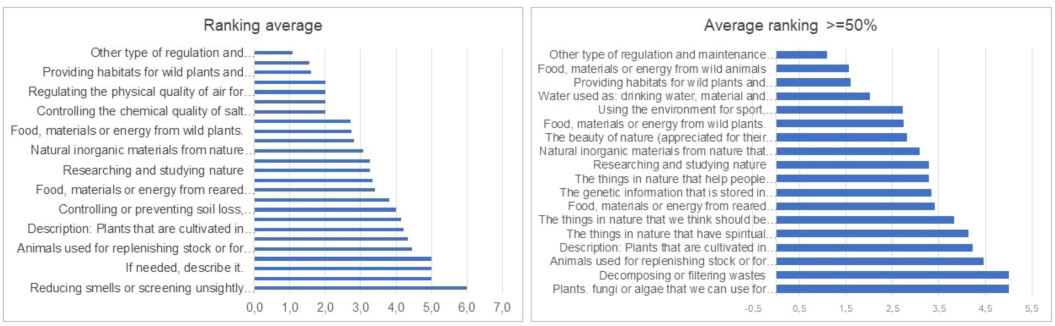

FIGURE 7
Black Sea. Left image: Ecosystem services ranking average. Right image: Ecosystem services ranking average from frequency higher than 50%.

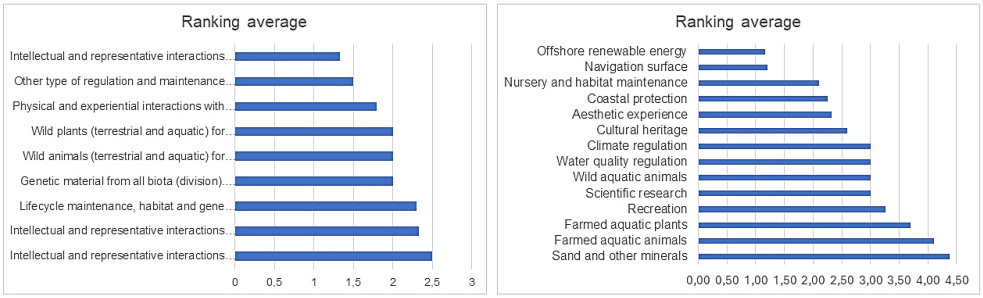

FIGURE 8
The Azores. Left image: Ecosystem services ranking average. The North-Sea. Right image: Ecosystem services ranking average.

It is also noteworthy that in the case of the North Sea, the service "Non-mineral substances or ecosystem properties used for nutrition, materials, or energy" reflects the importance of offshore wind energy in the area (Figure 8, right image). In the case of the Pelagos Sanctuary in the Mediterranean (Figure 6), the service "Food, materials or energy from reared animals" referring to "Reared aquatic animals for nutrition, materials, or energy" is highlighted. The case of the Azores stands out, where no importance is given to any provisioning service, even though the MPA is used for limpet harvesting. On the contrary, several cultural services were highlighted in the Azores. Two reasons stands out, one related to only one stakeholder from government answered the questionnaire, given a not representative answer for the area, or the high connection that the limpet harvesting activity has with the local and tradition community in the area.

The ecosystem services that fulfill most socio-economic criteria were those related to cultural services. For example, the service "Intellectual and representative interactions with the environment (abiotic and biotic)" was noted by CoP members in 13 out of 20 socio-economic criteria studied. Recall that socio-economic criteria were extracted from main policies, regulations, documents, and international agreements applicable to European countries (See Table 3). Considering this, the results obtained suggest that MPAs fulfill a role strongly linked to the socio-cultural well-being of the population. This arguably has implications for the management of these areas. Indeed, there is growing literature supporting the idea that MPAs should use a diversity of appropriate protection levels to achieve positive biodiversity outcomes (Andradi-Brown et al., 2023; Halik et al., 2018). This approach argues that partially protected MPAs—which allow certain marine activities within their borders—can offer effective and equitable pathways for biodiversity conservation if tailored to the local context (Andradi-Brown et al., 2023).

While this methodology was developed for the identification of socio-economic criteria and its application exhibits several limitations, certain identified outcomes prove valuable for discussions on MSP and MPA initiatives. It is essential to emphasize that the results presented in this study do not intend to capture the entirety of the most critical socio-economic criteria or the most valuable ES specific to each test site region. Instead, the aim of this research was to expand on Custodio et al. (2022), connecting ES with fundamental socio-economic criteria to be considered when planning and managing marine areas. Thus, maximizing equity and maintaining local livelihoods, while sustaining the natural capital on which their activities are based.

The methodology employed showcased potential for integrating the socio-economic dimension with the environmental and ecological aspects, primarily through its focus on ES. This integration is instrumental in aiding policymakers and stakeholders in recognizing and visualizing the interdependence between these dimensions, which constitutes a critical factor in promoting sustainable development and fostering cooperation among stakeholders.

In addition, the methodology presented addresses this critical gap by highlighting the interaction between socio-economic criteria and ES. It provides decision-makers in MPAs or marine planning areas with a more comprehensive understanding of the impacts of their choices, thus enabling more informed, equitable, and sustainable spatial management, providing a common ground for their integration and development. Since the criteria list is a result different policies, legislation and international documents, it supports the application of various European directives and national legislation, such as the European Union, the Marine Strategy Framework Directive (2008/56/EC)[1], the Marine Spatial Planning Directive (2014/89/EU)[2], the Habitats Directive (92/43/EEC)[3], the Birds Directive (79/409/EEC)[4] and even the European Green Deal[5]. At the national level, the method could enhance

1 A directive to protect the marine environment across European Union (EU) and ensure its sustainable use, guiding the overall environmental health of marine waters, including ecosystem health and human impacts

2 A directive that establishes a framework for maritime spatial planning, providing a structured approach to planning and managing marine areas for conservation and sustainable use.

3 A directive to protect natural habitats and wild species across EU, ensuring the protection of key habitats and species in marine and coastal environments, supporting biodiversity.

4 A directive to protect wild bird species in EU, focusing on the protection of bird species and their habitats, which often overlap with marine areas.

5 Aims for EU climate neutrality by 2050, including measures to protect biodiversity, reduce pollution, and promote sustainability, impacting marine environments as part of broader environmental goals.

compliance with the environmental legislation related to MPAs, marine planning and biodiversity conservation.

Moreover, both socio-economic and ecological processes are highly dynamic, and adapting management to change becomes of paramount importance. The methodology presented here not only provides a snapshot of the current state but also offers a framework for ongoing assessment and adaptation to evolving circumstances allowing for the tracking of stakeholder perceptions in the study areas.

The applied methodology also provided material for trade-off discussions. It offers a structured framework for assessing the trade-offs and synergies between different socio-economic criteria and ES, helping stakeholders make informed decisions that balance socio-economic development with environmental conservation. The identification of the main socio-economic criteria and ES allows for an informed selection of indicators to be mapped and integrated into the negotiation process.

5 Conclusions

Marine ES valuation plays a pivotal role in trade-off assessments, which are integral to MSP and MPAs. By conducting a quantitative analysis of the economic, ecological, and societal benefits derived from marine ecosystems, valuation enables decision-makers to make informed choices. It provides a scientific foundation for evaluating the trade-offs between conservation efforts and sustainable resource use within MSP. Ultimately, this approach helps optimize the allocation of MPAs, promotes ecological integrity, and ensures the long-term well-being of both marine ecosystems and the communities dependent on them.

It is important to acknowledge that certain aspects could not be fully addressed within the scope of this research. However, their significance must be recognized, and plans should be made for their integration into future work. Below are some potential points for consideration.

1. Allocate an extended timeframe for thorough explanation and training sessions for those responsible for executing the method. This will facilitate a deeper understanding of the methodology and its applications, enabling more effective implementation and standardization of the results.
2. Implement an additional workshop specifically designed for result validation at each test site. This workshop should ensure representation and balance of all stakeholder interests. Prior to the workshop, arrange a collective training session for all case study leaders responsible for conducting it. Additionally, allocate resources to enable in-person attendance at the validation workshop whenever feasible. This measure will enhance the credibility and precision of the findings by involving key stakeholders in the review and verification process. Furthermore, it will foster constructive dialogue among stakeholders to identify common ground, thereby improving the overall efficacy of the methodology.
3. Develop a map illustrating the ES of the analyzed area. This visual representation helps in understanding and contextualizing the ecological dynamics within the region under study, leading to better outcomes.
4. Develop indicators for the socio-economic context. This will support the assessment of the process as a whole.
5. Monitor and assess the ecosystems providing the services connected to the socio-economic criteria listed as high priority, thus closing the management cycle.
6. The scale of the test sites also plays a crucial role in the results of this study. Understanding how the integration of results might affect site-specific applications is important for future use of the outcomes presented here.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

CP: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. MD: Formal analysis, Methodology, Supervision, Writing – original draft. JG-O: Formal analysis, Methodology, Supervision, Writing – original draft. SR: Data curation, Writing – review & editing. JG-S: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. EU GRANT – Project: 101060707 — MSP4BIO — HORIZON-CL6-2021-BIODIV-01.

Acknowledgments

In this work, we would like to express our sincere gratitude to the MSP4BIO project for its invaluable support and funding. Special thanks go to the test sites leaders, that applied the methodology to their areas in the Azores (University of Azores: Helena Calado and Débora Gutierrez); North Sea (VLIZ: Inne Withouck, Fien De Raedemaecker, Isabelle Rombouts); Western Mediterranean (CEREMA: Neil ALLONCLE, Claire BOUDY; CNR: Roberta SCIASCIA and Marcello MAGALDI); Black Sea (CCMS: Hristo Stanchev and Margarita Stancheva); Baltic Sea (HELCOM: Kemal Pınarbaşı); for their insightful contributions and collaboration

throughout the research process. Also, the reviews of the final deliverable Margarita Stancheva and Riku Varjopuro for their comments and suggestions to improve the final document. Their expertise and dedication significantly enhanced the quality and impact of this study. We also acknowledge the entire MSP4BIO team for their support and encouragement. This research would not have been possible without their collective efforts. ChatGPT-4, developed by OpenAI, was used to enhance the readability of this work. The authors reviewed and edited the content as needed, taking full responsibility for the final version of the publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2024.1358950/full#supplementary-material

References

ACCOBAMS (2017). "Report of the Workshop on Inputs to the ACCOBAMS ongoing effort to map human threats on cetaceans in the Mediterranean and Black Seas," in *Paper presented at the 31st ECS Conference*, Middelfart, Denmark, April 30, 2017. Available at: https://www.accobams.org/wp-content/uploads/2016/06/Report_workshop_Threats_31_ECS.pdf. (Accessed November 20, 2023).

Agardy, T., Di Sciara, G. N., and Christie, P. (2011). Mind the gap: addressing the shortcomings of marine protected areas through large scale marine spatial planning. *Mar. Policy* 35, 226–232. doi: 10.1016/j.marpol.2010.10.006

Anderson, C. B., Athayde, S., Raymond, C. M., Vatn, A., Arias, P., Gould, R. K., et al. (2022). "Chapter 2: Conceptualizing the diverse values of nature and their contributions to people," in *Methodological assessment report on the diverse values and valuation of nature of the intergovernmental science-policy platform on biodiversity and ecosystem services*. Eds. P. Balvanera, U. Pascual, M. Christie, B. Baptiste and D. González-Jiménez (IPBES secretariat, Bonn, Germany). doi: 10.5281/zenodo.6493134

Andradi-Brown, D., Veverka, L., Amkieltiela,, Crane, N. L., Estradivari,, Fox Helen, E., et al. (2023). Diversity in marine protected area regulations: Protection approaches for locally appropriate marine management. *Front. Mar. Sci.* 10. doi: 10.3389/fmars.2023.1099579

Ansong, J., Gissi, E., and Calado, H. (2017). An approach to ecosystem-based management in maritime spatial planning process. *Ocean Coast. Manage.* 141, 65–81. doi: 10.1016/j.ocecoaman.2017.03.005

Ban, N. C., Gurney, G. G., Marshall, N. A., Whitney, C. K., Mills, M., Gelcich, S., et al. (2019). Well-being outcomes of marine protected areas. *Nat. sustainability* 2, 524–532. doi: 10.1038/s41893-019-0306-2

Barragán Muñoz, J. M., García Sanabria, J., and de Andrés García, M. (2020). ICZM strategy for the socioecological system of the Mar Menor (Spain): Methodological aspects and public participation. In A. Rubio Ortega (Ed.) *Socio-ecological studies in natural protected areas: Linking community development and conservation in Mexico* (Springer). pp. 243–272. doi: 10.1007/978-3-030-47263-4_12

Boonzaier, L., and Pauly, D. (2016). Marine protection targets: an updated assessment of global progress. *Oryx* 50, 27–35. doi: 10.1017/S0030605315000848

Cánovas-Molina, A., and García-Frapolli, E. (2020). Untangling worldwide conflicts in marine protected areas: Five lessons from the five continents. *Mar. Policy* 121, 104185. doi: 10.1016/j.marpol.2020.104185

CBD. (2021). *First draft of the post-2020 global biodiversity framework*. CBD/WG2020/3/3. Retrieved November 2023, from https://www.cbd.int/doc/c/914a/eca3/24ad42235033f031badf61b1/wg2020-03-03-en.pdf.

Coleman, H., Foley, M., Prahler, E., Armsby, A., and Shillinger, G. (2011). *Decision guide: Selecting decision support tools for marine spatial planning* (Palo Alto: Board of Trustees of the Leland Stanford Junior University), 56.

Cusack, C., O'Beirn, F., King, J. J., Silke, J., Keirse, G., Whyte, B. I., et al. (2008). *Water Framework Directive: Marine ecological tools for reference, intercalibration and classification (METRIC): Final report for the ERTDI-funded project 2005-W-MS-36. STRIVE Report 7*. (Environmental Protection Agency). Available online at: http://www.epa.ie/pubs/reports/research/water/strivereport7.html.

Custodio, M., Moulaert, I., Asselman, J., van der Biest, K., van de Pol, L., Drouillon, M., et al. (2022). Prioritizing ecosystem services for marine management through stakeholder engagement. *Ocean Coast. Manage.* 225, 106228. doi: 10.1016/j.ocecoaman.2022.106228

De Andrés, M., Barragán, J. M., and Sanabria, J. G. (2018). Ecosystem services and urban development in coastal Social-Ecological Systems: The Bay of Cádiz case study. *Ocean Coast. Manage.* 154, 155–167. doi: 10.1016/j.ocecoaman.2018.01.011

de Andrés, M., Muñoz, J. M. B., Onetti, J. G., and Zuniga, L. D. C. (2023). Mapping services for an ecosystem based management along the Andalusian coastal zone (Spain). *Ocean Coast. Manage.* 231, 106402. doi: 10.1016/j.ocecoaman.2022.106402

de Juan, S., Ospina-Alvarez, A., Castro, A. J., Fernández, E., Méndez-Martínez, G., Molina, J., et al. (2023). Understanding socioecological interaction networks in Marine Protected Areas to inform management. *Ocean Coast. Manage.* 245, 106854. doi: 10.1016/j.ocecoaman.2023.106854

Department for Environment, Food & Rural Affairs. (2012). *Marine strategy part one: UK initial assessment and good environmental status*. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69632/pb13860-marine-strategy-part1-20121220.pdf (Accessed November 20, 2023).

Dolch, T., Buschbaum, C., and Reise, K. (2013). *Schleswig-Holstein Wadden Sea Assessment of Phytobenthos (SHWAP) – die ersten 6 Jahre* (Flintbek, Germany: Symposium des Landesamts für Landwirtschaft, Umwelt und ländliche Räume).

Douvere, F. (2008). The importance of marine spatial planning in advancing ecosystem-based sea use management. *Mar. Policy* 32, 762–771. doi: 10.1016/j.marpol.2008.03.021

Driedger, A., Sletten, J., Colegrove, C., Vincent, T., Zetterlind, V., Claudet, J., et al. (2023). Guidance on marine protected area protection level assignments when faced with unknown regulatory information. *Mar. Policy* 148, 105441. doi: 10.1016/j.marpol.2022.105441

EC-CINEA, Burg, S., Chouchane, H., Kraan, M., Lizin, S., Daisden, T., et al. (2022). *Assessment of the relevance and effect of the Maritime Spatial Planning Directive in the context of the European Green Deal: Final report*. (European Commission, European Climate, Infrastructure and Environment Executive Agency, Publications Office of the European Union). doi: 10.2926/911941

EEA (2015). *Marine protected areas in Europe's seas. An overview and perspectives for the future. EEA Report* (Luxembourg: Publications Office of the European Union). doi: 10.2800/99473

Ehler, C. (2014). "A guide to evaluating marine spatial plans," in *IOC manuals and guides, 70; ICAM dossier 8* (UNESCO, Paris). Available at: https://unesdoc.unesco.org/ark:/48223/pf0000227779/PDF/227779eng.pdf.multi.

Ehler, C., and Douvere, F. (2009). *Marine spatial planning: A step-by-step approach toward ecosystem-based management* (Paris: UNESCO). Intergovernmental Oceanographic Commission and Man and the Biosphere Programme. IOC Manual and Guides No. 53, ICAM Dossier No. 6.

Erskine, E., Baillie, R., and Lusseau, D. (2021). Marine protected areas provide more cultural ecosystem services than other adjacent coastal areas. *One Earth* 4, 1175–1185. doi: 10.1016/j.oneear.2021.07.014

European Commission. (2018). *Directorate-general for maritime affairs and fisheries and joint research centre, the 2018 annual economic report on EU blue economy*, Publications Office of the European Union. Available online at: https://data.europa.eu/doi/10.2771/305342.

European Union. (1992). *Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Directive No. 92/43/*

EEC). Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31992L0043. (Accessed November 20, 2023)

European Union (2008). *Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)*. Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0056&from=EN (Accessed November 20, 2023).

Folke, C., Hahn, T., Olsson, P., and Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annu. Rev. Environ. Resour.* 30, 441–473. doi: 10.1146/annurev.energy.30.050504.144511

García-Sanabria, J., García-Onetti, J., Cordero Penín, V., de Andrés, M., Caravaca, C. M., Verón, E., et al. (2021). Marine Spatial Planning cross-border cooperation in the 'European Macaronesia Ocean': A participatory approach: *Mar. Policy*, 132, 104671. doi: 10.1016/J.MARPOL.2021.104671

Grau-Tomás, E., and García-Sanabria, ,. J. (2023). Comparative analysis of marine-protected area effectiveness in the protection of marine mammals: Lessons learned and recommendations. *Front. Mar. Sci.* 9. doi: 10.3389/fmars.2022.940803

Grorud-Colvert, J., Sullivan-Stack, C., Roberts, V., Constant, B., Horta e Costa, E. P., Pike, N., et al. (2021). The MPA Guide: A framework to achieve global goals for the ocean. *Science* 373 (6560), eabf0861. doi: 10.1126/science.abf0861

Haines-Young, R., and Potschin, M. B. (2018). *Common international classification of ecosystem services (CICES) V5.1 and guidance on the application of the revised structure*. Available online at: www.cices.eu. (Accessed November 20, 2023)

Halik, A., Verweij, M., and Schlüter, A. (2018). How marine protected areas are governed: A cultural theory perspective. *Sustainability* 10, 252. doi: 10.3390/su10010252

Halpern, M., Frazier, J., Potapenko, K. S., Casey, K., Koenig, C., Longo, J. S., et al. (2015). Spatial and temporal changes in cumulative human impacts on the world's ocean. *Nat. Commun.* 6, 7615. doi: 10.1038/ncomms8615

Halpern, B. S., Walbridge, K. A., Selkoe, C. V., Kappel, F., Micheli, C., D'Agrosa, C., et al. (2008). A global map of human impact on marine ecosystems. *Science* 319, 948–952. doi: 10.1126/science.1149345

HELCOM. (2012). *Development of a set of core indicators: Interim report of the HELCOM CORESET project. PART B: Descriptions of the indicators (Balt. Sea Environ. Proc. No. 129 B)*. (Helsinki Commission). Available online at: https://helcom.fi/wp-content/uploads/2019/08/BSEP129B.pdf (Accessed November 20, 2023).

International Maritime Organization. (2005). *Revised guidelines for the identification and designation of Particularly Sensitive Sea Areas (Resolution A.982(24))*. (International Maritime Organization). Available online at: https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/A24-Res.982.pdf (Accessed November 20, 2023).

Kriegl, M., Elías Ilosvay, X. E., von Dorrien, C., and Oesterwind, D. (2021). Marine protected areas: at the crossroads of nature conservation and fisheries management. *Front. Mar. Sci.* 8, 676264. doi: 10.3389/fmars.2021.676264

La Notte, A., D'Amato, D., Mäkinen, H., Paracchini, M. L., Liquete, C., Egoh, B., et al. (2017). Ecosystem services classification: A systems ecology perspective of the cascade framework. *Ecol. Indic.* 74, 392–402. doi: 10.1016/j.ecolind.2016.11.030

Lubchenco, J., and Grorud-Colvert, K. (2015). Making waves: The science and politics of ocean protection. *Science* 350, 382–383. doi: 10.1126/science.aad5443

Lubchenco, S. R., Palumbi, S. D., Gaines, S., and Andelman, S. (2003). Plugging a hole in the ocean: The emerging science of marine reserves. *Ecol. Appl.* 13, 3–7. doi: 10.1890/1051-0761(2003)013[0003:PAHITO]2.0.CO;2

Mangubhai, S., Wilson, J. R., Rumetna, L., Maturbongs, Y., and Purwanto, (2015). Explicitly incorporating socioeconomic criteria and data into marine protected area zoning. *Ocean Coast. Manage.* 116, 523–529. doi: 10.1016/j.ocecoaman.2015.08.018

Marcos, C., Díaz, D., Fietz, K., Forcada, A., Ford, A., García-Charton, J. A., et al. (2021). Reviewing the ecosystem services, societal goods, and benefits of marine protected areas. *Front. Mar. Sci.* 8. doi: 10.3389/fmars.2021.613819

Maund, P. R., Irvine, K. N., Dallimer, M., Fish, R., Austen, G. E., Davies,, et al. (2020). Do ecosystem service frameworks represent people's values? *Ecosystem Serv.* 46, 101221. doi: 10.1016/j.ecoser.2020.101221

McMichael, A., Hefny, M., and Foale, S. (2005). "Linking Ecosystem Services and Human Well-being," in *Ecosystems and human well-being: multiscale assessments; findings of the Sub-global Assessments Working Group of the Millennium Ecosystem Assessment* (1 ed., Vol. 1D. C. (Ed.), (Island Press), 43-60.

Miller, P. I., and Christodoulou, S. (2014). Frequent locations of oceanic fronts as an indicator of pelagic diversity: application to marine protected areas and renewables. *Mar. Policy* 45, 318–329. doi: 10.1016/j.marpol.2013.09.009

Müller, F. G. (2001). Environmental economics and ecological economics: antagonistic approaches. *Int. J. Environ. Stud.* 58, 415–443. doi: 10.1080/00207230108711342

Müller, F., Bicking, S., Ahrendt, K., Bac, D. K., Blindow, I., Fürst, C., et al. (2020). Assessing ecosystem service potentials to evaluate terrestrial, coastal and marine ecosystem types in Northern Germany–An expert-based matrix approach. *Ecol. Indic.* 112, 106116. doi: 10.1016/j.ecolind.2020.106116

Müller, F., de Groot, R., and Willemen, L. (2010). Ecosystem services at the landscape scale: the need for integrative approaches. *Landscape Online*, 23. doi: 10.3097/LO.201023

Peters, S. M., Guppy, R., Ramsewak, D., and Potts, A. (2023). Socioeconomic dimensions of the Buccoo Reef Marine Park, an assessment of stakeholder perceptions towards enhanced management through MSP. *ICES J. Mar. Sci.* 80, 1399–1409. doi: 10.1093/icesjms/fsad066

Potschin, M. B., Primmer, E., Furman, E., and Haines-Young, R. H. (2016). Have ecosystem services been oversold? A response to Silvertown. *Trends Ecol. Evol.* 31, 334–335. doi: 10.1016/j.tree.2016.03.008

Reed, M. S., Duncan, S., Mann, C., and Rauschmayer, F. (2021). Social learning, adaptive management and the wicked problem of sustainable development: Stakeholder participation in environmental management. *J. Environ. Manage.* 290, 112688. doi: 10.1016/j.jenvman.2021.112688

Rees, S. E., Pittman, S. J., Foster, N., Langmead, O., Griffiths, C., Fletcher, S., et al. (2018). Bridging the divide: Social–ecological coherence in Marine Protected Area network design. *Aquat. Conservation: Mar. Freshw. Ecosyst.* 28, 754–763. doi: 10.1002/aqc.2885

Reuchlin-Hugenholtz, E., and McKenzie, E. (2015). *Marine protected areas: Smart investments in ocean health* (Switzerland: WWF, Gland).

Rey-Valette, H., Mathé, S., and Salles, J. M. (2017). An assessment method of ecosystem services based on stakeholders' perceptions: The Rapid Ecosystem Services Participatory Appraisal (RESPA). *Ecosystem Serv.* 28, 311–319. doi: 10.1016/j.ecoser.2017.08.002

Rosales, R. M. P. (2018). SEAT: Measuring socio-economic benefits of marine protected areas. *Mar. Policy* 92, 120130. doi: 10.1016/j.marpol.2018.02.026

Salles, J. M., and Figuieres, C. (2013). "Current issues in ecosystem services valuation (ESV)," in *European Association of Environmental and Resource Economists 20th Annual Conference*, Toulouse, France, June 26-29, 2013, 1–22. Available at: https://agris.fao.org/search/en/providers/122652/records/6477611b5eb437ddff77d20a.

Santos-Martín, F., Montes, C., Alcorlo, P., García-Tiscar, S., González, B., Vidal-Abarca, M. R., et al. (2015). *La aproximación de los servicios de los ecosistemas aplicada a la gestión pesquera* (Madrid: Fondo Europeo de Pesca, Fundación Biodiversidad del Ministerio de Medio Agricultura, Alimentación y Medio Ambiente).

Science for Environment Policy (2018). *Indicators for sustainable cities. In-depth Report 12* (Bristol: Produced for the European Commission DG Environment by the Science Communication Unit, UWE). Available at: http://ec.europa.eu/science-environment-policy.

Sletten, M., D'lorio, M. G., Gleason, A., Driedger, A., Vincent, T., Colegrove, C., et al. (2021). Beyond the boundaries: How regulation-centered marine protected area information improves ocean protection assessments. *Mar. Policy* 124, 104340. doi: 10.1016/j.marpol.2020.104340

SPA/RAC–UN Environment/MAP (2019). *Guidelines for strengthening the sustainable socio-economic role of Mediterranean Marine and Coastal Protected Areas*. Ed. M. Pascual (Tunis: MedMPA Network Project), 30.

Sy, M. M., Figuières, C., Rey-Valette, H., Howarth, R. B., and De Wit, R. (2022). Valuation of ecosystem services and social choice: The impact of deliberation in the context of two different aggregation rules. *Soc. Choice Welfare*, 59 (2), 123-145. doi: 10.1007/s00355-022-01421-7

Termansen, M., Jacobs, S., Mwampamba, T. H., Ahn, S., Castro, A., Dendoncker, N., et al. (2022). "Chapter 3: The potential of valuation," in *Methodological assessment report on the diverse values and valuation of nature of the intergovernmental science-policy platform on biodiversity and ecosystem services*. Eds. P. Balvanera, U. Pascual, M. Christie, B. Baptiste and D. González-Jiménez (IPBES secretariat, Bonn, Germany). doi: 10.5281/zenodo.6521298

Trouillet, B., and Jay, S. (2021). The complex relationships between marine protected areas and MSP: Towards an analytical framework. *Mar. Policy* 127, 104441. doi: 10.1016/j.marpol.2021.104441

United Nations Convention on the Law of the Sea (UNCLOS). (2023). *Draft agreement under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction. (March 4, 2023)*. Available online at: https://www.un.org/bbnj/sites/www.un.org.bbnj/files/draft_agreement_advanced_unedited_for_posting_v1.pdf (Accessed November 20, 2023).

UNEP. (2017). *Mediterranean quality status report. Integrated monitoring and assessment programme of the mediterranean sea and coast*. Available online at: https://www.medqsr.org/integrated-monitoring-and-assessment-programme-mediterranean-sea-and-coast/ (Accessed November 20, 2023).

UNEP/MAP-SPA/RAC (2020). SPAMIs in the mediterranean - january 2020. Available online at: https://www.rac-spa.org/sites/default/files/doc_spamis/liste_aspim_2020.pdf (Accessed November 20, 2023).

UNESCO. (2023). Operational guidelines for the implementation of the World Heritage Convention (WHC.23/01). (Paris, France: United Nations Educational, Scientific and Cultural Organization. Available online at: https://whc.unesco.org/en/guidelines/.

UNESCO-IOC/European Commission. (2021). *MSPglobal international guide on marine/maritime spatial planning* (Paris: UNESCO. (IOC Manuals and Guides no 89). Available at: https://unesdoc.unesco.org/ark:/48223/pf0000379196.

Vaughan, D., and Agardy, T. (2020). "Marine protected areas and MSP–allocation of resource use and environmental protection" *Marine protected areas* . (Elsevier), 13–35. doi: 10.1016/B978-0-08-102698-4.00002-2

Withouck, I., De Raedemaecker, F., Georgiou, P., Gutierrez, D., Calado, H., Costa, A. C., et al. (2023). *) Summary report of existing criteria, species and habitat lists used in conservation and restoration initiatives (Deliverable – D2.2., under the WP2 of MSP4BIO*

project (GA n° 101060707). MSP4BIO. Available online at: https://msp4bio.eu/publications/.

WWF. (2021). *Ecosystem-based Maritime Spatial Planning in Europe and how to assess it* (Brussels, Belgium: WWF European Policy Office, WWF-Portugal, WWF-Spain). Available online at: https://wwfeu.awsassets.panda.org/downloads/wwf_eb_maritime_spatial_planning_guidance_paper_march_2021.pdf.

WWF (2022a). *Assessing the balance between nature and people in European Seas: Maritime Spatial Planning in the North-East Atlantic Ocean*. WWF European Policy Office, WWF-Portugal, WWF-Spain, Brussels, Belgium. https://wwfeu.awsassets.panda.org/downloads/wwf_north_east_atlantic_msp_assessment_2022.pdf.

WWF (2022b). *Maritime spatial planning in the north-east atlantic – technical annex* (Belgium: WWF European Policy Office). Available at: https://wwfeu.awsassets.panda.org/downloads/wwf_north_east_atlantic_msp_assessment_2022:_technical_annex.pdf.

WWF (2022c). *Maritime spatial planning in the north sea – technical annex* (Belgium: WWF European Policy Office). Available at: https://wwfeu.awsassets.panda.org/downloads/wwf_north_sea_msp_assessment_2022:_technical_annex.pdf.

Zupan, M., Bulleri, F., Evans, J., Fraschetti, S., Guidetti, P., Garcia-Rubies, A., et al. (2018). How good is your marine protected area at curbing threats? *Biol. Conserv.* 221, 237–245. doi: 10.1016/j.biocon.2018.03.013

Zupan, M., Fragkopoulou, E., Claudet, J., Erzini, K., Horta e Costa, B., and Gonçalves, E. J. (2018a). Marine partially protected areas: drivers of ecological effectiveness. *Front. Ecol. Environ.* 16, 381–387. doi: 10.1002/fee.1934