

# Participatory mapping of uses and ecosystem services as a useful tool for the identification of conflicts in Marine Protected Areas: The case of the Cíes Islands archipelago (NW Spain)

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## ABSTRACT

Marine Protected Areas (MPAs) aim to preserve marine natural capital and reduce marine biodiversity loss. However, due to the diversity of objectives in marine planning, their management involves the resolution of conflicts on current uses and ecosystem services. Participatory mapping is a useful technique in MPA's management that uses local knowledge to map ecosystem services and associated conflicts and threats. The goal of this study was to analyse the stakeholders' perception on uses and ecosystem services in the Cíes Islands archipelago, located in the National Park of the Galician Atlantic Islands. Results from semi-structured questionnaires conducted with different stakeholders, indicated that landscape values and marine research were the most valued ecosystem services, although slight differences were found between fishers and other sectors. The activities exerting the highest pressure on the protected area were fishing and tourism. Conflicts were mainly associated with the co-existence of activities within the MPA, potentially threatening conservation goals. Participatory mapping helped to identify MPA management actions to achieve conservation objectives while maintaining current uses and activities in the future.

## 1. Introduction

Marine ecosystems provide important goods and services for society (Tonin, 2018). Impacts derived from human activities (e.g., over-exploitation of resources, habitat degradation, pollution, invasive species) together with emerging demands on marine habitats and resources have generated growing governmental concerns leading to the implementation of measures aimed at the long-term preservation of marine ecosystem services provision through the creation of marine protected areas (MPAs) (Kelly et al., 2014; Batista and Cabral, 2016). According to the International Union for Conservation of Nature (Day et al., 2019, p. 9), "MPAs are clearly defined geographical spaces, recognised, dedicated and managed, through legal or other effective means, to achieving the long-term conservation of nature with the associated ecosystem

services and cultural values". However, MPAs are designed to address a wide range of purposes, such as protecting marine biodiversity and habitats, maintaining ecosystem services, restoring fish stocks, managing several economic activities (e.g. small-scale fishing and recreational activities), minimising conflicts between resource users or reducing poverty (Mazaris et al., 2019). This multiplicity of objectives is often difficult to achieve simultaneously, and thus, many existing MPAs are ineffective and even "paper parks" (Relano and Pauly, 2023), i.e. they exist in legal terms, but are virtually non-existent in terms of protecting natural resources and delivering the socio-economic benefits for which they were created (Di Cintio et al., 2023). In this regard, it has been estimated that only 9% of the total number of parks have a high management level and are able to achieve their management objectives (Thur, 2010). Given that MPAs cannot be considered successful until

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they achieve the defined conservation objectives, a better understanding of anthropogenic pressures on marine ecosystems is expected to increase its effectiveness (Roberts et al., 2018).

Social and political acceptance of conservation plans in marine environments requires the analysis of benefits provided by MPAs to people (Saunders et al., 2015). In this sense, the complexity of socio-ecological relationships makes it necessary considering the social context that shapes conflicts and marine conservation, including interests and perceptions at the local level. When MPAs are properly planned and managed, they can play a key role in achieving conservation and sustainable management goals within the marine domain (Mazaris et al., 2019).

Our research is based on the conceptual framework of marine and coastal ecosystem services. In this context, ecosystem services mapping has been pointed as a critical means to bring ecosystem services into practical application, thereby contributing to sustainable management of MPAs (Burkhard and Maes, 2017), yet the inclusion of maps and mapping tools in real world decisions is still limited. In addition, the current evidence suggests that distinct ecosystem services' mapping routines are applied without distinction to these disparate purposes, an aspect of ESs mapping that has deserved very little attention by the scientific community so far (Manea et al., 2019).

Methods currently used for this purpose are based on participatory mapping exercises through questionnaires and expert knowledge. Both methods are informative tools that allow stakeholders to participate in decision-making processes while providing critical insight into the identification of key threats. As a result, they can be used to target conservation investments and to recognize the appropriate scales for implementing management actions (Mazaris et al., 2019; Karnad, 2002). However, mapping studies are still exploratory academic exercises guided by the technical expertise of researchers and usually disconnected from real world problems that decision-makers confront. Only a few articles defined mapping goals jointly by researchers and decision makers (Nahuelhual et al., 2020); these studies aim at creating decision-making tools for particular marine areas. Our study, that has been designed to provide evidence and practical solutions to real problems of the study site, also goes beyond the current state of the art by jointly co-designing mapping and analyzing the ecosystem services. In addition, the use of participatory mapping not only provides a methodology capable of identifying potential hotspots in the coastal areas, but also generates previously unknown social data, providing an innovative, adaptive and stakeholder-driven approach. This enables the joint development of participatory tools for marine spatial planning, conservation management and coastal development strategies at multiple scales (Moore et al., 2017; Burdon et al., 2019).

This study was carried out at the Cíes Islands archipelago, in the Maritime-Terrestrial National Park, a MPA characterized by a relatively high faunistic, floristic and landscape diversity and its geological and geomorphological interest. Traditionally, the Cíes Islands' fishing grounds have been one of the main sources of socio-economic livelihood for local fishing communities (Fernández et al., 2020). However, in the last few years, the popularity of the islands grew steadily, increasing the pressure due to recreational activities. Enhanced tourism interacting with other marine uses and activities may result in environmental impacts and represent a potential risk for the ecological integrity of the MPA.

The aim of this study was to investigate how mapping of ecosystem services (ES) based on stakeholders' perception may contribute to address conflict and threats in the MPA management. To achieve this goal, face-to-face interviews and a participatory mapping exercise of activities and uses within the area were carried out. By adopting this methodological approach, we could identify perceived threats and potential conflicts derived from different uses and users that may affect biodiversity conservation and, thereby favour the identification of actions leading to improved MPA management plans.

## 2. Material and methods

### 2.1. Study area

The Cíes Islands's archipelago is located in the northwest of the Iberian Peninsula (NE Atlantic), 14.5 km from the city of Vigo (Galicia) and is constituted by three main islands and four islets, covering a total area of 3091 ha, of which 433 ha are terrestrial and 2658 ha marine (Fig. 1). They form the Maritime-Terrestrial National Park of the Atlantic Islands of Galicia, together with the archipelagos of Ons, Sálvora and Cortegada. According to the IUCN classification based on the primary stated management objective of the MPA (Day et al., 2019), the Cíes Islands archipelago should be included in Category II with the exception that the Spanish legislation does allow the operation of traditional artisanal resource extraction activities within MPAs.

The Cíes Islands were declared Natural Park in 1980, when a protection regime based on their geological, botanical, faunistic, and historical-archaeological values was established. Later, in 2002, the Cíes Islands were declared National Park. Due to the attractiveness of its landscapes and beaches, the number of visitors has increased significantly since the 1980s. For example, in 2013, the influx of tourists to the Cíes Islands has been increasing to reach 300,000 visitors per year, with some peaks of visitors above the carrying capacity of the archipelago (Fernández et al., 2020). That context highlighted the need for a protection regime not only derived from the island's natural values but also from their uses and activities. In 2018, the Use and Management Master Plan (Decree 177/2018, 2018) (hereafter UMMP) was approved, what included the Guiding Plan for Use and Management of the Maritime-Terrestrial National Park of the Atlantic Islands of Galicia.

In addition, the Cíes Islands have planning and management instruments, such as the Galician Natura 2000 Network Master Plan, which includes the Special Protection Area for Birds, since 1988 (ES0000001 ZEPa), Special Area of Conservation, since 2014 (ES0000001 ZEC) and Galician Rías Baixas Marine Area (ZEPa ES0000499). This planning and management instruments allow implementing the protection regime derived from the Birds Directive and the Habitats Directive, the provisions of the regional regulations, Law May 2019 on natural heritage and biodiversity of Galicia, and state regulations, such as Law 42/2007, on natural heritage and biodiversity and Law 30/2014 on national parks. The objectives and guidelines derived from its declaration as a protected area by international instruments within the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), as a Wetland of International Importance (Ramsar Site) or its inclusion on the BirdLife international's marine Important Bird Area (IBA) programme are also of application in the Cíes Islands.

### 2.2. Selection of ecosystem services

The environmental regulation affecting the Cíes Islands under the National Park protection figure together with the relatively low anthropic pressures they experience (Fernández et al., 2020) maintained ecosystem integrity at a reasonable level. This conferred an excellent opportunity for studying ecological processes both at the global and local scale and have even been considered a "natural laboratory" by scientists and experts. The landscapes offered by the archipelago are very diverse. Its terrestrial relief, made up of cliffs, dunes and beaches, and the rocky, sandy or Maërl and gravel seabed, allow the settlement of an important number of species of both flora and fauna, creating a scenario of colours and shapes of great beauty. These features also provide a wide range of recreational opportunities based on the enjoyment of nature. Sun and beach tourism play a very important role in the MPA, coexisting with sailing, diving and snorkelling, the latter two are among the experiences most valued by visitors (Pineiro-Corbeira et al., 2014).

The status of the Cíes Islands archipelago as a national park prohibits



**Fig. 1.** Descriptive panel of the Cíes Islands archipelago. A) Location of the Cíes Islands archipelago in the Vigo estuary. B) Photograph of Rodas beach and C) Photograph showing San Martiño Island and the channel separating the archipelago.

any exploitation of raw materials, except for traditional activities that have been maintained over time. For this reason, its waters are accessible to an artisanal inshore fleet, which has been fishing in the islands for centuries, comprising around 565 vessels (Ourenés et al., 2015) and where the octopus’s fishery, shellfishing of bivalves afloat, exploitation of barnacles and shellfishing by free-diving for razor clams and sea urchins (Tellado et al., 2014) are particularly important, with some of the exploited species having a high economic value.

The selection of the ES used in this study was based on the main characteristics of the MPA described above together with a bibliographic review of the scientific publications and projects that have been developed in the archipelago, which are referenced Fernández et al. (2020). Following this procedure 11 ecosystem services were identified: climate regulation (CICES code 2.2.6.1), nutrient cycling (CICES code 2.2.5.2), coastal protection (CICES code 2.2.1.4) and habitat provisioning (CICES

code 2.2.2.3), recreational activities and tourism (CICES code 3.1.1.1 and 3.1.1.2), educational activities (CICES code 3.1.2.2), research activities (CICES code 3.1.2.1), landscape value (CICES code 3.1.2.4) and cultural identity (CICES code 3.1.2.3), those related to fishing and shellfishing activities (CICES code 1.1.6.1).

### 2.3. Questionnaire’s design and stakeholders’ selection

The design of the questionnaire aimed to first obtaining information about the background of the interviewees, their use of the MPA and their opinion about the current status of the archipelago. Secondly, they were asked to elicit and prioritise the ES importance in the area. It is worth mentioning that, for the subsequent analysis of these assessments, corrections were made based on the qualitative information obtained during the interviews. This was particularly relevant for interviewees who

initially assigned high scores to certain uses and ES but demonstrated limited knowledge about the topic during in-depth questions. Thirdly, to find out the respondents perception of the relationship between uses and/or ES and the components of human well-being, they were asked to rate these relationships on a scale from 0 to 10 based on their perceived according to the attributed relevance. Finally, in-depth questions were formulated aiming at unveiling the knowledge of interviewees on the uses and ES associated with the archipelago, identifying through participatory mapping the areas where activities are carried out and finding out those interactions between uses that could generate possible threats and/or conflicts and the possible solutions they consider feasible to face these threats and conflicts. In addition to identifying areas for different uses and ES, respondents were asked to rate the importance of these areas for each use and ES on 0 to 10 scale. The questionnaire is shown in Appendix A.

The interviewees were selected considering their direct relationship with the archipelago. Five key groups were identified: MPA managers (those responsible for MPA management); leisure & tourism companies (private actors involved in leisure activities, outdoor sports, etc.); environmental NGOs (associations and groups focussed on environmental protection); researchers (academics and experts who have carried out scientific research in the Cíes islands); fishing sector (professional fishers and shellfishers). The relative representation of each key group, depending on the willingness of each sector to participate in the interviews, was: 25% research; 25% NGOs; 21% leisure and recreational companies; 17% administration; and 12% fishing sector. A total of 24 interviews were conducted between August and November 2020. Due to the restrictions derived from the COVID-19 pandemics, 13 of the interviews were conducted by video call. The duration of the interviews ranged from 1h to 3h. To test for statistically significant differences between the perceptions of ecosystem services provided by each sector, a Kruskal-Wallis non-parametric test was used. QGIS 3.22.11 software was used to analyse the cartographic information collected from the interviews.

2.4. Identification of actions for the improvement of MPA management

Actions for the improvement of the MPA management were retrieved from two phases of the methodological approach followed in this investigation. First, respondents were asked during the interviews to identify initiatives that might help in overcoming the threats and

conflicts they recognize. In a further step, the results of the analysis of the participatory mapping exercise were presented to the respondents in two workshops where they validated the spatial distribution of uses and services and, whenever possible, they were inquired to propose actions aimed at improving the management of those areas where potential conflicts are likely to arise.

3. Results

3.1. Stakeholders' perception of ecosystem services importance

The stakeholders' perception regarding ES provided by MPA is shown in Fig. 2. All ES were highly rated. The highest scores were obtained by the ES "Marine research", "Landscape value" and "Habitat provisioning". "Leisure and relaxation", "Cultural identity" and the recreational activities "Kayaking, diving and snorkelling" and "Sailing" obtained average ratings (6.5–7).

Statistically significant differences were detected in stakeholders' perception of the ES importance for "Climate regulation" (p < 0,05), "Nutrient cycling" (p < 0,05) and "Marine research" (p < 0,05). In these cases, the ratings given by the fishing sector were significantly lower than those provided by the other sectors in the case of "Climate regulation", by the leisure & companies and environmental NGOs sectors for "Nutrient cycling" and by the leisure & companies sector for "Marine research". In contrast, the fishing sector was the only one perceiving "Cultural identity" as one of the main ES (9 ± 0.2), although this difference in perception was not statistically significant compared the rest of stakeholders' groups.

3.2. Participatory mapping of marine ecosystem services

3.2.1. Spatial distribution of the frequency of recognised ES supply

The marine uses and ES most recognised and which occupy the whole marine area of the archipelago were "Fishing", "Cetacean watching", "Interest for research" and "Landscape value", followed by "Shellfishing" and "Perception of biodiversity", which were recognised in areas adjacent to the coastal limit of the archipelago (Fig. 3). However, differences were observed in the frequency of recognition of some ES such as "Fishing" and "Interest for research" for which the highest frequency of recognition was located in the channel separating the two main islands. In the case of "Landscape value" and "Shellfishing" the

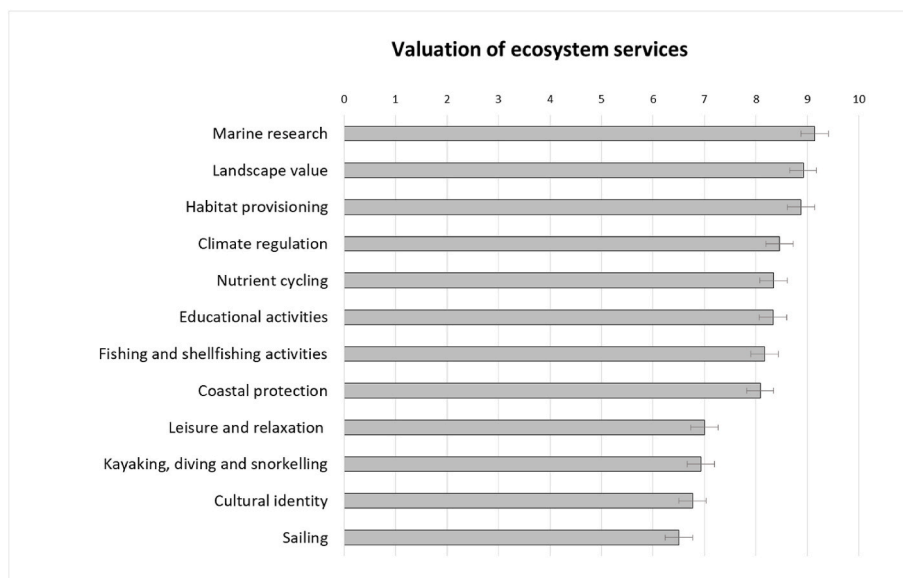
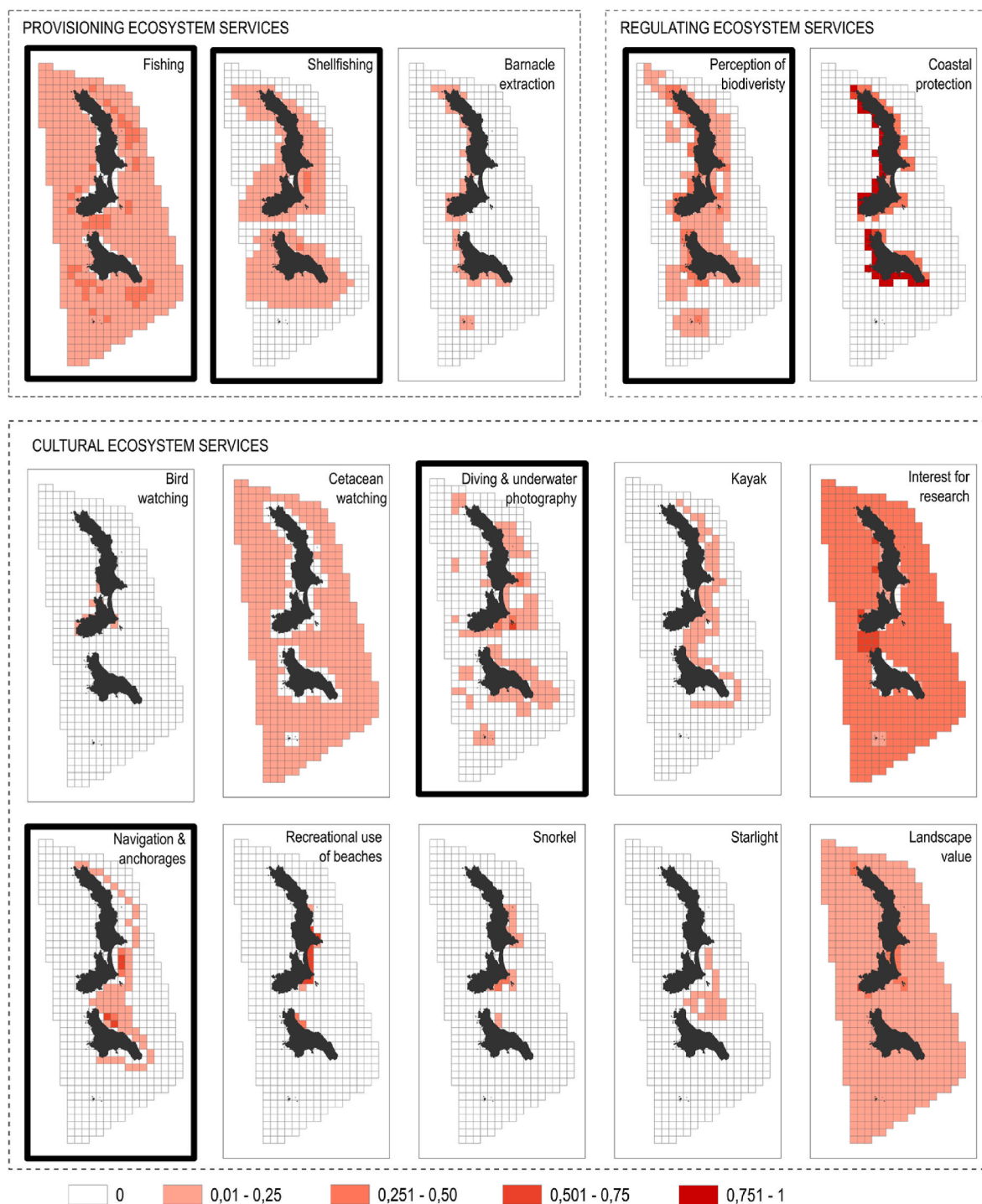


Fig. 2. Average ratings achieved by the different ES provided by the archipelago, derived from the results of the interviews. The range of importance is from 0 to 10, with 0 being "not at all important" and 10 "very important".



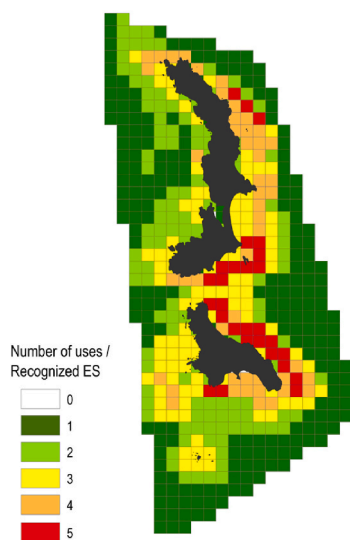
**Fig. 3.** Spatial distribution of the frequency of recognition of the uses and ES analysed in the Cíes Islands archipelago. The increase in colour intensity indicates a higher frequency of recognition by respondents. Grid size: 250 x 250m.

frequency of recognition was higher in various areas of the inner archipelago. In contrast, the uses recognised in specific areas of the archipelago’s protected coastline were “Recreational use of beaches” located in the sandy areas, “Kayak” and “Navigation and anchorages”, which almost completely overlap, except that for the latter as some areas in front of the sandy areas for the anchoring of recreational boats were reported. In contrast, “Diving and underwater photography” occupies slightly larger areas than the previous recreational uses. Finally, “Coastal protection” and “Barnacle extraction” are mainly recognised in the offshore side of the archipelago.

The five uses and ES that were prioritised by the interviewees are highlighted in black in Fig. 3. These ES and their interactions in the marine area will be analysed in detail in the following sections.

### 3.2.2. Spatial overlapping of marine uses and ES

Fig. 4 shows the spatial overlap of the five prioritised uses and ES in the archipelago. Our results show that as the distance from the shoreline increases, the number of interactions decrease. Similarly, there is a greater accumulation of marine uses and ES in the inner side of the archipelago, where even four and five uses an ES spatially overlap, than on



**Fig. 4.** Spatial distribution of overlapping of the five marine uses prioritised. Variables represented: “Fishing”; “Shellfishing”; “Perception of biodiversity”; “Diving and underwater photography” and “Navigation and anchorages”. Each grid represents the number of uses and ES recognised by interviewees. Grid size 250 x 250m.

the exposed side, where the number of ES or uses occurring in the same grid is generally lower than 3.

### 3.2.3. Spatial distribution of the importance of marine uses and ES

Fig. 5 represents the spatial distribution of the importance that was assigned to the prioritised uses and ES by the interviewees. The most valued area for the development of “Fishing” was the channel separating the two main islands together with an area located on the northern inner side of the Monteagudo Island, followed by several small areas located on the exposed offshore side of the archipelago, which were also recognised as very important for “Perception of biodiversity”. The most important areas for “Shellfishing” are located along the inner side of the archipelago, overlapping with important areas for both “Diving and underwater photography” and “Navigation and anchorages”. These areas were also identified as important for these three last uses coincide with those recognised for “Perception of biodiversity”.

### 3.2.4. Spatial distribution of pairwise interactions of marine uses and ES

Fig. 6 shows the interactions between the prioritised pairs of uses and ES considering the importance assigned to each zone. The main

interactions (in red) take place in the inner zone of the archipelago. For example, the “Shellfishing”-“Navigation and anchorages” interaction, located in the Rodas beach or the “Perception of biodiversity”-“Diving and underwater photography” interaction located around the Islet of Viños.

Other areas where relevant interactions occur (in orange) were identified in the north of Monteagudo Island, as for “Shellfishing”-“Navigation and anchorages”, although, in this case coinciding with the interaction “Perception of biodiversity”- “Navigation and anchorages”. The channel area was also recognised as relevant for the “Shellfishing”-“Perception of biodiversity” interaction. The remaining interactions between pairs of uses and ecosystem services (in green and yellow) were mostly located along the protected coastline of the archipelago (Fig. 7).

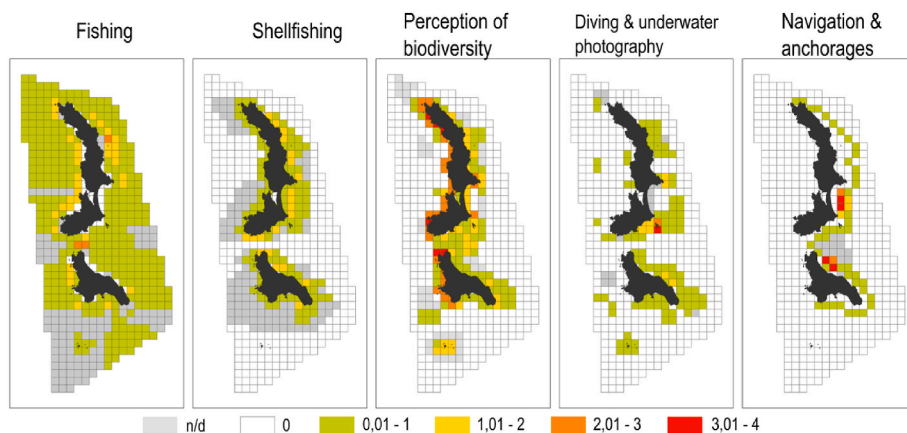
### 3.2.5. Overlapping of marine uses and ES with the MPA spatial planning

The analysis of the overlapping among the five selected ES allowed identifying areas of high intensity of interactions (in red and orange) and therefore, where conflicts can potentially arise (Fig. 7). These critical areas are firstly located close to the San Martiño beach where passenger transport lines do not operate. So, the interactions are mainly established between visitors arriving on board their own boats and anchoring close to the beach and intensive “Fishing” and “Shellfishing” activities. Secondly, south of Rodas beach and around the islet of Viños, in Faro Island, where the high biodiversity coincides with “Diving and underwater photography”, as well as “Shellfishing”. Finally, an intense interaction between “Fishing”, “Shellfishing”, “Diving, underwater photography” and “Navigation and anchorages” also takes place in the area around the channel.

When the spatial distribution of the intensity of the interactions is superimposed on top of the spatial planning defined for the MPA, in the areas established as “marine zone of moderate use on the surface and reserve in depth”, no interactions were identified. The areas established as “marine zone of moderate use on the surface and restricted in depth” in the Use and Management Plan, are those where most uses overlap (Fig. 7) being fishing, shellfishing and anchoring the uses potentially affecting the seabed with a higher intensity. In addition, this overlapping occurs in areas close to the coast and at shallow depths (<10m).

## 3.3. Marine protected area threats and conflicts

The main threats identified by respondents for the Cíes Islands were linked to fishing and shellfishing activities (83% of respondents), recreational activities and tourism (79% of respondents) and the current management model of the archipelago (67% of respondents) (Fig. 8). In the case of fishing and shellfishing activities, the lack of regulation



**Fig. 5.** Spatial distribution of the importance of prioritised uses and ES. Grid size 250 x 250m. When the interviewees recognised for a specific use in a given area but did not assign a value corresponding to their importance, the average of the evaluations of the rest of the interviewees who did assign a value to that area were used. Once this value had been assigned, the average of all the interviewees (n = 24) was calculated, resulting in the range from 0 to 4 shown in the figure.

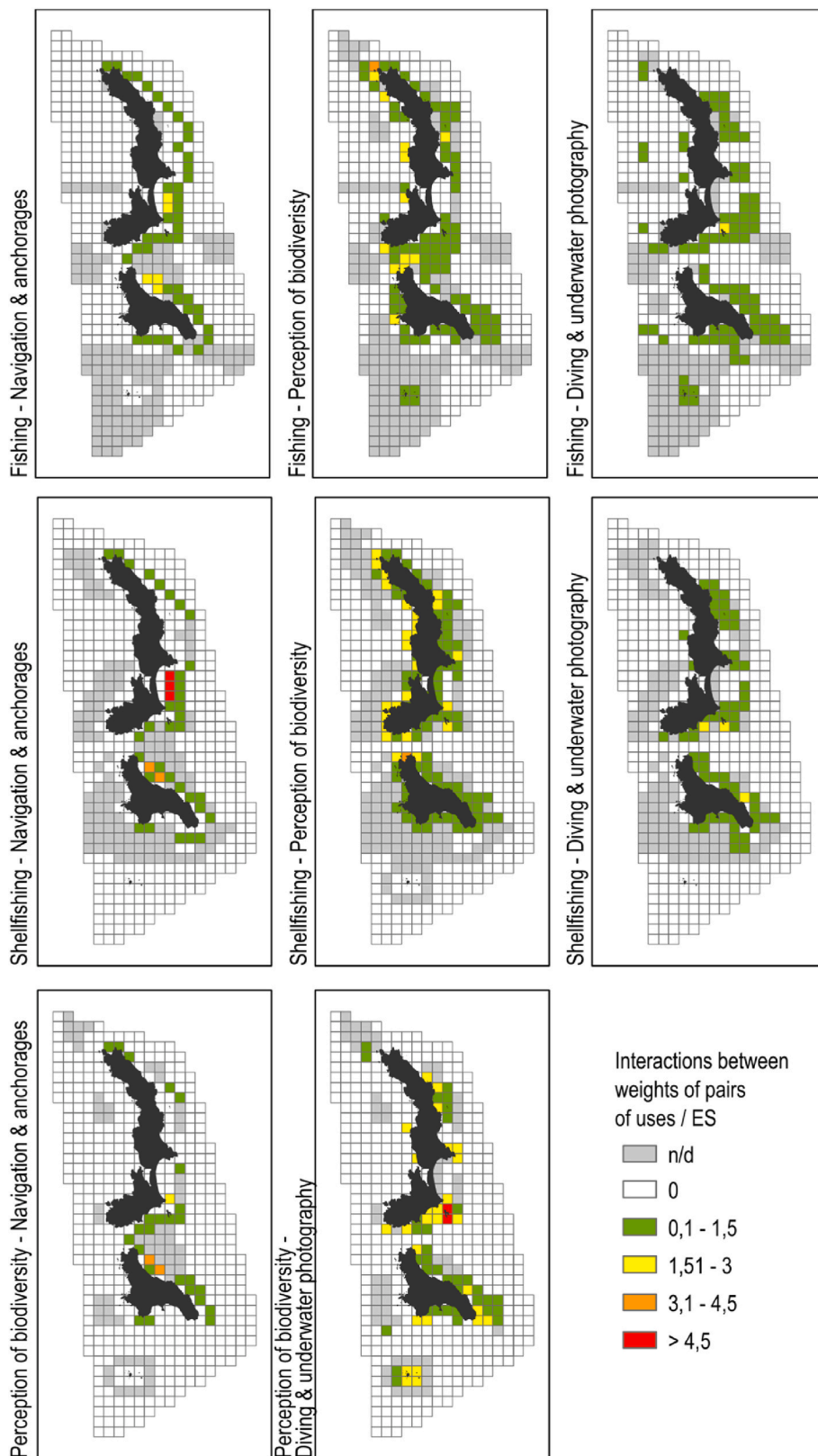


Fig. 6. Spatial distribution of the interactions between the prioritised pairs of uses or ES. Grid size 250 x 250m.

adapted to the particularities of the MPA (58% of respondents) and the impact of some fishing gears (e.g. trammel nets), anchors and boat engines on marine biodiversity (38% of respondents) were the main threats identified.

The most relevant threats of recreational activities and tourism were

associated with the peaks of visitors during the summer months (79% of respondents) and revealed the disagreement generated by the current daily quota of visitors. The impact of recreational boating and anchoring on the marine ecosystems of the archipelago was also a highly recognised threats (58% of respondents).

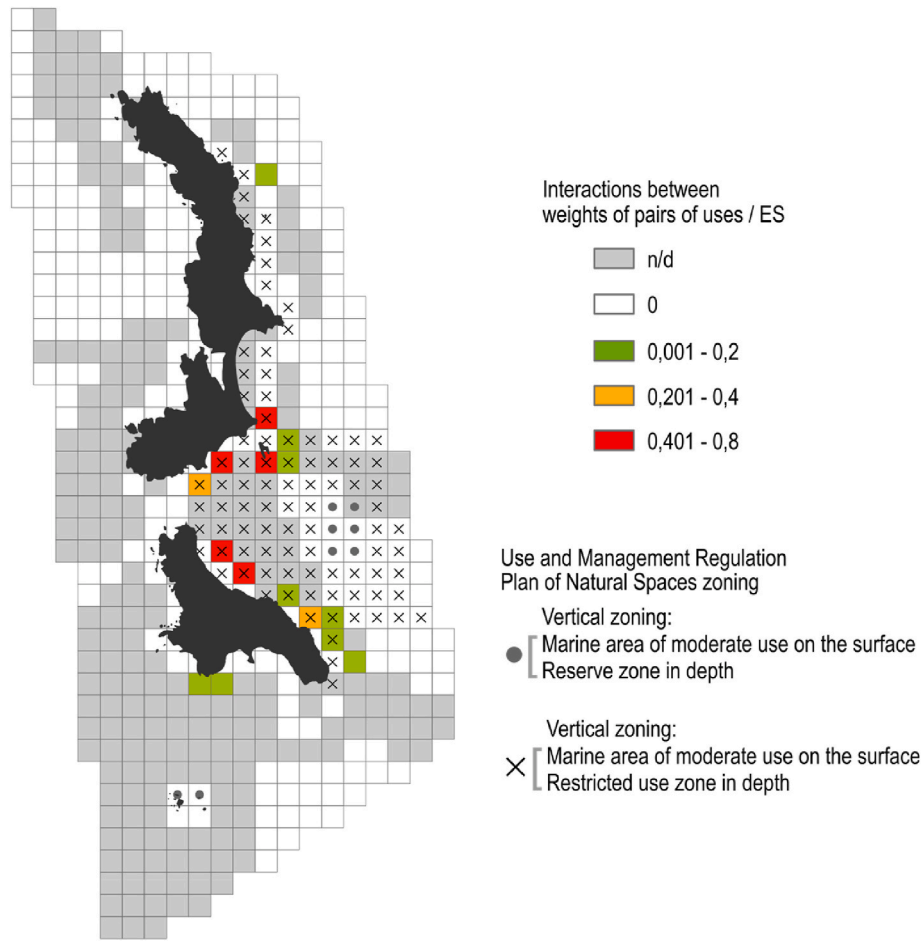


Fig. 7. Spatial distribution of the intensity of interactions between the five selected uses and ES: “Fishing”, “Shellfishing”, “Navigation and anchorages”, “Diving & underwater photography” and “Perception of biodiversity” and spatial zoning defined in the Use and Management Plan of Natural Spaces of the MPA. Grid size 250 x 250m.

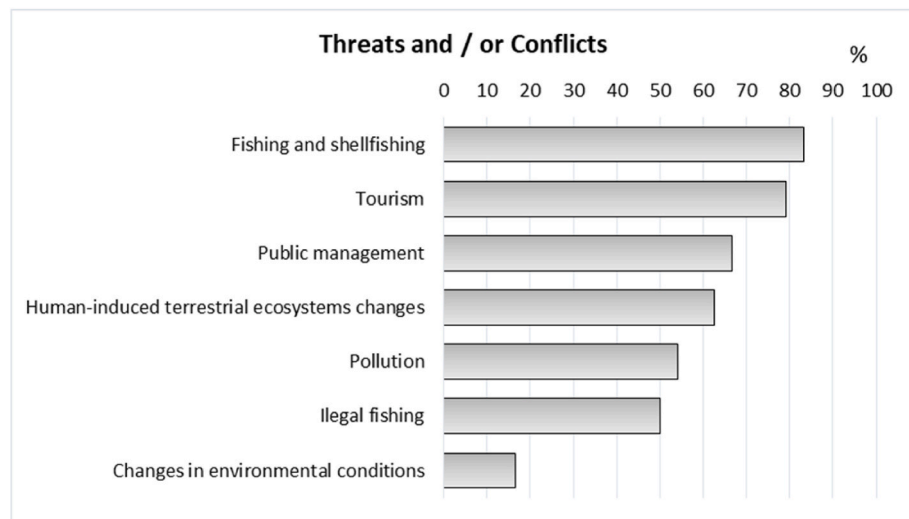


Fig. 8. Relative importance of the threats and/or conflicts detected by the respondents. The figure indicates the category of the threat and/or conflict, and the percentage of the total number of respondents (n = 24 interviews).

The aspects most frequently mentioned by interviewees in relation to the MPA management were the disagreements between social actors arising from conflicts of interest between the socio-economic uses of the archipelago and the conservation of natural values. For example, they

highlighted the importance of increasing research funding (33%) or modifying the focus of the promotion initiatives that are currently being developed for the archipelago (17%).

Other threats recognised by the social actors were the human

impacts on the terrestrial component of the archipelago. For example, landscape impact of constructions and artificial infrastructures or the massive reforestation with pines, eucalyptus and acacias that took place in the middle of the 20th century. Threats related to pollution and discharges into the sea (e.g., small losses of diesel oil, wastewater, outfalls, etc.), poaching and environmental issues such as climate change and ocean acidification were also recognised.

### 3.4. Proposed actions for the improvement of MPA management

The main actions proposed by interviewees for the improvement of the MPA management are compiled in Table 1. Fisheries and shellfishing are the pressures with the greatest number of proposed actions. These actions are focused on the development of new resource management plans that should consider the natural values of the archipelago. Actions related to the pressure exerted by the influx of visitors to the archipelago also received considerable attention. Delimitation of navigable areas together with a readjustment in the areas where anchoring is allowed are the main actions for improvement related to the access to the archipelago through private vessels, either they disembark or not in the archipelago. In this regard, it was proposed that anchorage should be

**Table 1**  
Actions proposed by interviewees aiming at the improvement of MPA management.

Pressures	Proposed actions
Fisheries and shellfishing management	Fisheries and shellfishing plans based on the specific characteristics of the archipelago. Creation of flexible marine reserves, allowing their closure or opening based on scientific evidence (adaptive management considering changes in the population of exploited species). Elimination of harmful fishing gear through the purchase or by setting maximum extinction periods. Promote consumption of new species as an adaptation to climate change-driven changes in fish and shellfish communities. Reducing fishing and shellfishing pressure.
Navigations and anchorages	Banning recreational boating at the San Martiño Island Establish specific zones for anchoring recreational boats. Keep shipping routes away from areas of ecological interest. Reduce the number of boats and anchorages currently permitted.
Tourism	Restrict access by delimiting areas of use and passage. Reducing visitor quotas based on carrying capacity. De-seasonalise visits to the archipelago.
Research, monitoring and evaluation	Increase research funding Independent projects per National Park. (priority is currently given to those involving several national parks) Coordination between research projects and research groups.
Vessel traffic	Development of initiatives to stop using the Cíes as a refuge area for merchant ships. Set pollution limits per ship.
Structures and constructions	Establish minimum criteria for landscape integration and sustainability (in terms of visual impact). Replacement of the current pier by low-impact infrastructure.
Illegal fishing	Increase penalties. Improve control and surveillance (Increasing surveillance personnel, night surveillance ...).
Environmental education	Increase the dissemination of the projects carried out in the National Park. Improve capacitation of the personnel of the MPA by increasing training (e.g. environmental guidelines).
Image & advertising	Promote the archipelago based on its ecological values and on local and traditional activities.
Invasive alien species (IAS)	Eradication of IAS and restoration/reintroduction of native species (e.g. <i>Zostera marina</i> ).

forbidden in the island of San Martiño. In the case of access to the Islands through shipping companies and further disembarking in the archipelago, (i.e. “Tourism”) de-seasonalisation, readjustment of the visitor quotas and a strict delimitation of access areas are the main actions proposed. The interviewees also highlighted the need to increase investment and improve the coordination among the research projects being developed in the MPA, to modify the image of the archipelago by emphasizing its natural values, and to allocate more resources to surveillance and control services, thus achieving a greater compliance with the regulations.

## 4. Discussion

### 4.1. Local knowledge on ecosystem services

MPAs worldwide often help users to identify and value their intrinsic and relational values through its natural and cultural components and not only as a source of material benefits to people (Ocelli Pinheiro et al., 2021). The fact that all the ES were highly valued by interviewed stakeholders reflect the strong connection between this MPA and local stakeholders. Specifically, the highest scores obtained by “Marine research”, “Landscape value” and “Habitat provisioning”, mostly related to the opportunities that the marine realm provides to people, can be explained by the protection status of this MPAs compared to areas disturbed by human activities (Marcos et al., 2021). In this sense, the ecological diversity that characterises the Cíes Islands, together with the high variety of landscapes that confer the archipelago a high ecological value (Fernández et al., 2020), could explain the high value observed.

In contrast, “Cultural identity” and the recreational activities such as “Kayaking, diving and snorkelling” and “Sailing” showed a different pattern with lower values of importance. It is worth mentioning that the only sector that consider important “Cultural identity” ES was the fishing sector, which can be related to the historical and traditional character of artisanal fisheries in the region. Galicia’s economy is highly dependent on fishing, not only in terms of fish and shellfish production and employment, but also because of the relationships this activity establishes with other local economies (Cambié et al., 2012). The most recent data indicate that this activity accounts for 5% of the community’s GDP (Fisheries Yearbook, 2023) Specifically, the impact of artisanal fisheries on the local economy in the Ría de Vigo is estimated in around 41,9 million € in 2010 (Surís-Regueiros et al., 2014).

The practice of outdoor recreational activities such as “Kayaking, diving and snorkelling” and “Navigation”, showed an increasing trend in recent years (Davenport and Davenport, 2006). However, this increase has been limited in the Cíes Islands due to the legislative framework and protection status that establishes a maximum number of visitors per day, controls of recreational boats through the issuing of authorisations and to the seasonal nature of these activities, usually carried out in summer. In this regard, it has been estimated that approximately 1% of the users of the Cíes Islands practice some form of diving and whereas only a small fraction of visitors is interested in snorkelling (Piñeiro-Corbeira et al., 2014).

The significant differences found among the fisheries sector and other stakeholders with regards to “Marine research” is likely to be related to the proximity of this sector to the natural resource, what usually tends to favour economic benefits derived from resource exploitation over conservation values (Newig and Fritsch, 2009). In the case of the perception of “Climate regulation” and “Nutrient cycling”, a greater importance for the maintenance of these ES has been generally reported for stakeholders with a broader knowledge on environmental issues and, consequently, more environmental awareness (Castro et al., 2011).

### 4.2. Threats and conflicts identified in the Cíes Islands MPA

The increase of human activities such as fishing, transport or energy

generation in coastal areas, together with the growing global demand for recreational uses in natural spaces, exert multiple pressures on the marine environment. These pressures lead to a progressive degradation of habitats and landscapes (Dailianis et al., 2018; MEA, 2005). The interactions described in this study occur within a MPA and, consequently, most of the threats identified are related to the conservation of natural values. For instance, the two main uses, fishing and shellfishing activities, as well as tourism, were recognised by stakeholders as the main pressures currently exerted on the MPA. These uses could even jeopardise some of the most vulnerable marine ecosystems of the archipelago. By contrast, threats associated with climate change or ocean acidification were not perceived as significant for biodiversity conservation by the interviewees. This could be due to the fact that, while scientific evidence of these processes exists in the study area (Padín et al., 2020), the associated impacts on ecosystem health are largely unknown. In addition, ocean acidification is still a relatively recent concept for society (Gkargkavouzi et al., 2019).

The results derived from the participatory mapping exercise showed some degree of overlapping between the marine uses and ecosystem services provided by the MPA. In some areas uses such as recreational activities, fishing and shellfishing overlap with areas of high ecological importance. For example, the northern inner side of the Monteagudo Island, provides important spawning areas for Octopus (*Octopus vulgaris*) (Guerra et al., 2015) and kelp forests of great ecological value as ecosystem engineers and fostering a high diversity of fauna but currently in regression (Piñeiro-Corbeira et al., 2022). The second zone, from the islet of Viños and Carracido, on the Faro Island to Bicos Cape, on the San Martiño Island, provides habitats for emblematic synnathids species. These species have special characteristics that make them susceptible to various human-induced threats, including habitat loss, physical disturbances, and degradation caused by coastal development through boating and shipping or fishing practices like trawling and dredging (Hernández-Urcera et al., 2021; Piñeiro-Corbeira et al., 2021).

Furthermore, within this zone it is located a Maërl seabed (Peña, 2009), a coastal habitat of high diversity and productivity (Peña and Bárbara, 2008). Islands cliffs are habitats for seabird species such as the European Shag (*Phalacrocorax aristotelis*) considered one of the most outstanding natural assets of the National Park. These seabirds use the eastern side of the islands for feeding during the breeding season (Velando and Munilla, 2011) and play a key role in the productivity of the nearby microbial plankton communities (Justel-Díez et al., 2023). The ecological characteristics of these two areas make them relevant for the supply of provisioning and cultural ecosystem services, being identified by the interviewees as areas of great importance for fishing and shellfishing activities (Piñeiro-Corbeira et al., 2022), as well as for recreational activities such as diving and sailing. Notably, the channel between the two main islands experiences the more intense nautical pressure within the archipelago (Velando and Munilla, 2011).

The overlapping of marine uses within the MPA could lead to trade-offs among users involved. Conflicts frequently emerge from actors perceiving other key sectors as their opponents and, as a result, tend to prioritise its own activity over the others (De Groot, 2006). This is the case, for example, for the conflict found between the recreational and commercial fishing sectors. Recreational users felt displaced by fishing, while fishers considered that recreational activities hinder its professional practice.

Our results also show that some of the identified conflicts are frequently related to failures in the communication and information procedures among stakeholders' interests. For example, the research and environmental NGOs sectors indicated a lack of information on the impact of fishing and recreational activities on MPA ecosystems. These activities potentially threaten biodiversity conservation either through the anchoring of boats or the use of trawling gear. This lack of information partly derives from one of the main problems identified for the effective governance of the MPA, i.e., the fragmentation of regulatory competences among different institutions. Competences on fishing and

shellfishing regulation within the MPA are completely independent of the MPA managers, which makes challenging for stakeholders to engage in effective communication and information exchange. In addition, official information is often unavailable or biased, as it usually corresponds to ports where the vessels are registered rather than to the fishing grounds where species are captured (Cambié et al., 2012). It has found that when there is no effective and inclusive communication of information, transparency and reputation can be undermined (Semitiel-García and Noguera-Méndez, 2019). This, in turn, may increase the likelihood and intensity of conflicts, or further may jeopardise the ability of the marine realm to preserve the diversity of ES which many users rely on (Kelly et al., 2014).

Threats and conflicts identified in this study may have been influenced by tensions between the socio-economic uses of the archipelago and the conservation of the MPA. This conclusion emerges from two interrelated aspects. Firstly, the collection of spatially explicit information requires continuous monitoring and assessment of the MPAs under study to identify critical areas where vulnerability assessments of habitats and species should be undertaken, and stressors might be reduced or eliminated (Dailianis et al., 2018). Secondly, because socioecological monitoring through participatory exercises helps keeping all stakeholders involved in the process, thus securing their knowledge perceptions, interests and expectations are equally represented, in MPA management (Cárcamo et al., 2014; Kelly et al., 2014). In this context, it has been reported that when the agents involved participate in the elaboration and monitoring of the management plans, the established objectives are satisfactorily achieved (Álvarez-Fernández et al., 2020). Our results suggest that management based on spatial planning of activities and their associated pressures can be an effective tool for MPA management, as it aims at keeping the MPA in a healthy status and, at the same time, maintaining the supply of ES and promoting resilience (Kelly et al., 2014).

Our contribution goes beyond the current state-of-the-art by unravelling the key importance of analyzing spatial distribution of marine ecosystem services, synergies and trade-offs between users, trends and plausible solutions within the interdisciplinary research on MPA. This study has shown that participatory mapping of marine uses allowed identifying areas where several, sometimes incompatible, uses occur. The concentration and overlap of uses could hinder the effectiveness of the MPA, including its sustainable use or enjoyment by users. However, hotspot maps only indicated areas of overlapping of marine uses and are not necessarily the most threatened or more accessible. Therefore, this information should be combined with a complementary assessment of pressures, trade-offs, vulnerability and resilience (Nahuelhual et al., 2020). In this sense, the participatory mapping tool also provided a visualization of the spatial distribution of the different activities and associated conflicts in the Cíes Islands archipelago, thereby facilitating the proposal of potential consensual actions emerging from stakeholders aiming at the reduction of conflicts between users while avoiding possible impacts on key species. The main action proposed for the improvement of MPA management was the restrictive management of uses and activities based on specific studies of the MPA. For example, through the creation of flexible marine reserves or the definition of shipping routes away from areas of ecological interest. However, according to the interviewees, implementation of this action would require the construction of a fluid dialogue and exchange of information between stakeholders in order to generate better and a more complete while holistic knowledge on the MPA pressures, thus allowing an effective regulation of tourism, fishing and shellfishing activities. The information obtained from the participatory mapping can be useful for decision-makers to establish MPA new conservation and management priorities (De Andrés et al., 2023).

We are aware that the results obtained in this study elicit participants' responses and that a different sample may express a diverse perception in relation to actions to be implemented (Nahuelhual et al., 2020). However, the inherent flexibility to the methodological approach

allows for tailored actions to be developed together with stakeholders. This ensures that the process is appropriate for sustainable coastal and marine management purpose and at the same time, improves the knowledge on the socio-cultural values associated with the ecosystem services provided by these ecosystems and on the trade-offs between these services determining societal well-being (Burdon et al., 2019). In this case study, dialogue between MPA stakeholders was encouraged for the identification of management actions, which not only raised societal awareness among the leisure, tourism, fishing and shellfishing sectors of the benefits of conserving the natural values of the archipelago, but also facilitated the development of a strategic management plan that incorporates specific actions not currently included in existing regulations.

The participatory mapping exercise provided detailed geospatial data on the distribution of different uses, ecosystem services and associated conflicts in the Cíes Islands archipelago that can inform spatial planning. This tool also facilitated the proposal of possible consensual actions that, arising from stakeholders, will help managing trade-offs between conservation and sustainable use of marine resources. In the case of the Cíes Islands, the local knowledge acquired from participatory mapping facilitated the identification of areas with a high concentration of uses, which may lead to the development of specific regulations. However, the UMMP currently in force only establishes a vertical zoning of activities in the MPA, i.e. between the surface and the seabed, but it does not establish an organisation of uses in the surface water layer, which favours the between-users conflicts identified in this study. Furthermore, our results show that, although some of the actions proposed by the interviewees are already included in the regulation as, for example, the creation of marine reserves or the need to promote more sustainable tourism or fishing and shellfishing farming, they do not seem to be adopted in a consensual manner by all the parties involved. By contrast, other proposed actions are not considered by the current regulation, such as the need to delimit navigation zones adjusted to the different uses. For this reason, it is recommended that when developing future actions to improve the management of the MPA, the perspective of the users should be taken into account to achieve an effective MPA in which the objectives of biodiversity conservation and sustainable development are attained.

The application of the participatory mapping method, along with the illustrative example of Cíes Island considering multiple marine ecosystem services and users with contrasting outcomes, could provide valuable guidance for scientists, practitioners, and decision-makers to be able to respond in a flexible way to social-ecological changes on MPA protected areas in the pursuit of ocean sustainability.

#### 4.3. Policy implications

Marine Protected Areas (MPAs) are the foremost policy tool for marine conservation at both international and local levels (Jones et al., 2023; Picone et al., 2021) as they operate as complex socio-ecological systems where humans and nature interact (Di Franco et al., 2020). Yet, research on the human dimension and social impacts of MPAs has been limited (Bennett et al., 2016). It has been shown that the effectiveness of MPAs is substantially hampered by governance shortcomings (e.g., lack of participation) and capacity shortfalls (e.g., inadequate management processes). In this framework, the United Nations Decade of Ocean Science for Sustainable Development (2021–2030) has called for co-developing science for the oceans of the future, and both the Sustainable Development Agenda (United Nations, 2015) and the Kunming-Montreal Global Biodiversity Framework (2022) highlight the need for knowledge generation processes to improve understanding of socio-ecological systems and identify transformative solutions for coastal and marine challenges (Mills et al., 2023).

Our results from the Cíes Islands archipelago illustrate a lack of consensus on the current management tools operating in the MPA, particularly in relation to the trade-off between the socio-economic activities carried out in the area and the biodiversity conservation

regulations. Deficient communication with an inadequate involvement of stakeholders in participatory planning processes of MPA or the adoption of planning approaches not sufficiently based on adaptive management, are the foundations of the existing conflicts in the MPA due to the absence of common objectives among stakeholders (Miles et al., 2020).

Improvement of participatory and decision-making processes has been identified as a critical need to achieving effective governance in the Cíes Islands MPA. Collaborative, active and transparent participation will enable the adoption of decisions through negotiation and compromise, thereby attaining more equitable benefits for the different groups of interest (Islam et al., 2017) due to the provision of local knowledge and solutions, especially from underrepresented groups, tailored to specific contexts and local needs. This type of participatory processes prepare the ground for more effective implementation and monitoring of long-term policies, legitimize marine resource governance, and effectively develop individual and collective learning capacities through action (Nenadovic and Epstein, 2016). The adoption of a bottom-up approach whereby MPA users become more aware of the management processes may be an effective option to fulfil the objectives of sustainable development defined in the MPA (De Oliveira Júnior et al., 2021). In addition, gaining understanding on how stakeholders value and depend on the ES supplied by the MPA, would allow including local priorities into the conservation management tools and identifying how they could be affected by the MPA management decisions (Nadine et al., 2022). In our study, the use of participatory mapping allowed identifying MPA zones where multiple uses and users coexist and where the management regulations of the different activities should be reviewed, ideally leading to the development of a specific zoning plan through community-based management (Islam et al., 2017).

The use of knowledge co-production through participatory processes, along with the illustrative exercise conducted in the Cíes Island considering different actors and with different (and sometimes contrasting) outcomes, can provide valuable guidance to achieve the objectives of the Use and Management Master Plan of the Maritime-Terrestrial National Park of the Atlantic Islands of Galicia. Our results could also provide practitioners and decision-makers new pathways to improve the effective management of other MPAs aiming at addressing international targets while providing flexible responses to the spatial and temporal changes in the supply of ecosystem services by MPAs in the pursuit of sustainability.

## 5. Conclusions

Managing conflicts between marine conservation goals and human activities is one of the most pressing challenges in the management of MPA. The Cíes Islands Archipelago, a space of well-recognised natural beauty, ecological richness, and cultural heritage, is one of the most visited MPA in Spain, while it also supports the livelihood of multiple coastal fishing communities. The evolution over time of these marine uses and activities has generated several conflicts among users and threats that demand the adoption of new adaptive and more effective management tools. Our study shows how mapping of marine ecosystem services based on stakeholders' perception may contribute to identify critical trade-offs where the human activities developed in the MPA overlap with each other and with areas of high ecological importance. This methodological approach has also been a useful tool translating these trade-offs potential threats and conflicts which in turn may affect biodiversity conservation goals in the MPA. The participatory mapping approach also facilitated the co-production of local knowledge from diverse stakeholders that can serve to locally inform the Guiding plan for the use and management of the Maritime-Terrestrial National Park of the Islands. This co-production approach also empirically illustrates how the implementation of participatory tools for marine spatial planning may be useful for improving management and coastal development strategies in other MPAs experiencing similar conservation conflicts.

## CRediT authorship contribution statement

**J. Molina-Urruela:** Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation. **E. Fernández:** Writing – review & editing, Visualization, Validation, Supervision, Methodology, Conceptualization. **A.J. Castro:** Writing – review & editing, Supervision, Methodology, Conceptualization. **M. Expósito-Granados:** Writing – review & editing, Methodology, Investigation. **A. Ovejero-Campos:** Writing – review & editing, Software, Methodology, Data curation. **S. Villasante:** Writing – review & editing, Visualization, Validation, Supervision, Investigation, Conceptualization. **G. Méndez-Martínez:** Writing – review & editing, Visualization, Validation, Supervision, Software, Resources, Methodology, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix. ASupplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ocecoaman.2024.107474>.

## Data availability

Data will be made available on request.

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