Chapter 24
Can Local Knowledge of Small-Scale Fishers Be Used to Monitor and Assess Changes in Marine Ecosystems in a European Context?

Cristina Piñeiro-Corbeira, Sara Barrientos, Rodolfo Barreiro, Shankar Aswani, José J. Pascual-Fernández, and Raquel De la Cruz-Modino

Significance Statement In the last decades, many coastal areas have observed dramatic changes in marine ecosystems, due to anthropogenic and environmental alterations. The general absence of long-term data sets in the marine environment and, more specifically, on benthic and demersal communities represents a severe issue for management and conservation. We propose to incorporate the small-scale fishers' knowledge and science for better policy recommendations, both in terms of fisheries optimization and resource conservation. Based on two different cases of study with diverse ecosystems, we explore the combination of quantitative and qualitative tools, and participative techniques used to incorporate fishers' local ecological knowledge. The results highlight fishers' capacity to identify coastal and marine landscapes resources and changes, reinforcing and complementing the scientific assessment.

Keywords Fisher's knowledge · Small-scale fisheries · Participatory mapping · Marine recovery

C. Piñeiro-Corbeira · S. Barrientos · R. Barreiro
BioCost, Faculty of Science and Centro de Investigaciones Científicas Avanzadas (CICA), University of A Coruña, A Coruña, Spain

S. Aswani
Departments of Anthropology and Ichthyology and Fisheries Science, Rhodes University, Grahamstown, South Africa

J. J. Pascual-Fernández · R. De la Cruz-Modino (✉)
Instituto Universitario de Investigación Social y Turismo, Universidad de La Laguna, La Laguna, Tenerife, Spain
e-mail: rmodino@ull.edu.es

I. Misiune et al. (eds.), *Human-Nature Interactions*,
https://doi.org/10.1007/978-3-031-01980-7_24

1 Introduction

In recent decades there has been a push to use Local Ecological Knowledge (LEK hereafter) in the design and participatory monitoring and management of Marine protected Areas (MPAs hereafter) worldwide. While many of these studies have occurred in indigenous areas or small coastal communities in developing nations (e. g. Silvano & Begossi, 2012; Mellado et al., 2014), there is a growing effort to include LEK in the design of MPA areas and their monitoring and management in developing nations too (e. g. Scholz et al., 2004; Davies et al., 2018). In the context of Europe, these efforts are still limited, and a few proposals have incorporated LEK into MPA design and monitoring (Burns et al., 2020), despite there being an increasing interest to enhance local participation and compliance (Higgins et al., 2008). This investigation expands on these efforts by examining the use of LEK to monitor and manage European MPAs. In this regard, we consider the incorporation of small-scale fishers' LEK as a value-added for coastal fisheries research, monitoring, and management with the assumption that fishers' LEK can be an essential component in collaborative strategies and community-based management schemes (Gerhardinger et al., 2009), particularly in the monitoring of short and long-term changes in MPAs in Spain. In this study, we explore the fishers' perception of abundance for different species and fishers' behavior and effort displacement in two different contexts where the severe reduction of different benthic populations is being studied due to natural and anthropogenic changes. In the first case, after a volcano eruption affecting an MPA, we were interested in detecting any fishing displacement, leading to an increase in operational costs. Considering the ecosystem-services provided by this MPA (Roncin et al., 2008), we also wanted to know the level of fishing usage of the MPA and the main species target around it and associated LEK. In the second case, we explore the potential of fishers' knowledge to assess long-term-changes in crucial marine habitats. Kelp forests are essential to maintaining the local fleet's small-scale fisheries around the MPA, but there is a lack of information about kelp forest changes in this MPA and areas nearby. Here, we looked for their historical distribution and regression and their associated central fisheries.

1.1 Case of Study Characterization

This study was carried out in two MPAs in Spain: (1) The Marine Reserve (MR hereafter) of Punta de la Restinga and Sea of Calms (El Hierro, Canary Islands) and (2) the Islas Atlánticas de Galicia National Park (IANP hereafter). There are several MPA designations in Spain, including MR, National Park (NP hereafter), Protected Biotopes, and Fishing Reserves, among others with different stakeholder involvement degrees (De la Cruz Modino & Pascual-Fernández, 2013). MPAs also be established for various purposes (Jentoft et al., 2011), including fishing

sustainability and allowing for some forms of small-scale fisheries within the protected areas. In this regard, in some MPAs, small-scale fishers participate in the MPAs management and maintenance through their *cofradías*[1] or fisher organisations (Bavinck et al., 2015) with the State and regional officials.

The case of Punta de la Restinga and Sea of Calms MR is an example of how small-scale fishers may participate in the design and monitoring/management of MPAs' from *step zero* (Jentoft et al., 2012), thus increasing their governability as well as the MR's role in stakeholder's synergy building and fostering community development (Pascual-Fernández et al., 2018). The Sea of Calms is historically the main fishing area for the small-scale fishers from La Restinga village, and the MR implementation helped protect this sensitive area where small-local-fishing boats can fish year-round (De la Cruz Modino, 2012). In October 2011, the submarine volcano *Tagoro* erupted on El Hierro Island's Southwest coast, just in La Restinga coast – see Fig. 24.1. The Sea of Calms was heavily affected, and fishing activities were completely officially banned for almost a year. Since then, only a few studies have researched the role of the MR in the recovery, except by Mendoza et al. (2020), who argued that the no-take zone showed more resilience than the buffer and fished zones in the MR. This research suggests that no-take zones are crucial in the recovery process after catastrophic events (Mendoza et al., 2020).

A possible displacement of the fishing effort and changes in small-scale fishers' behavior could indicate the volcano's effects on the benthic communities, and the fishing concentration efforts around the MR may support Mendoza's conclusions. In this regard, a mapping process was initiated with fishermen's collaboration, under the premise that local knowledge was accurate enough and possibly complementary to scientific knowledge, as daily fishers' experience updates it. Participatory mapping (Aswani & Lauer, 2006) was not only considered as an affordable tool for assessing the fisheries recovery because it provides practical information on the status of fishing areas after the volcano's eruption, but also because it can help to evaluate the role of local monitoring of the MPA in this context. This technique was also chosen to further the involvement of fishers and other local stakeholders in the area's different projects after the eruption.

In the other case study, similarly Galician *cofradía*s have historically participated in the dialogue between fishers, scientists, and decision-makers, facing important community initiatives for guaranteeing fishing activity, resource management, and the viability of the small-scale fishery in the long term (Frangoudes et al., 2008; Perez de Oliveira, 2013). Kelp forests are one of the main habitats in temperate coastal ecosystems that provide essential ecological and socio-economic ecosystem services to local small-scale fisheries. However, their decline has been reported worldwide in the last decades (Vergés & Campbell, 2020); NW Spain (Barrientos

[1] *Cofradías* are non-profit public corporations, the most important fisher organizations in Spain, which represent this sector and take roles of consultation and cooperation for the administration, while undertaking economic, administrative, and commercial management tasks (Bavinck et al., 2015; Pascual-Fernández, 1999). They have played an important role in the implementation of Marine Reserves in Spain.

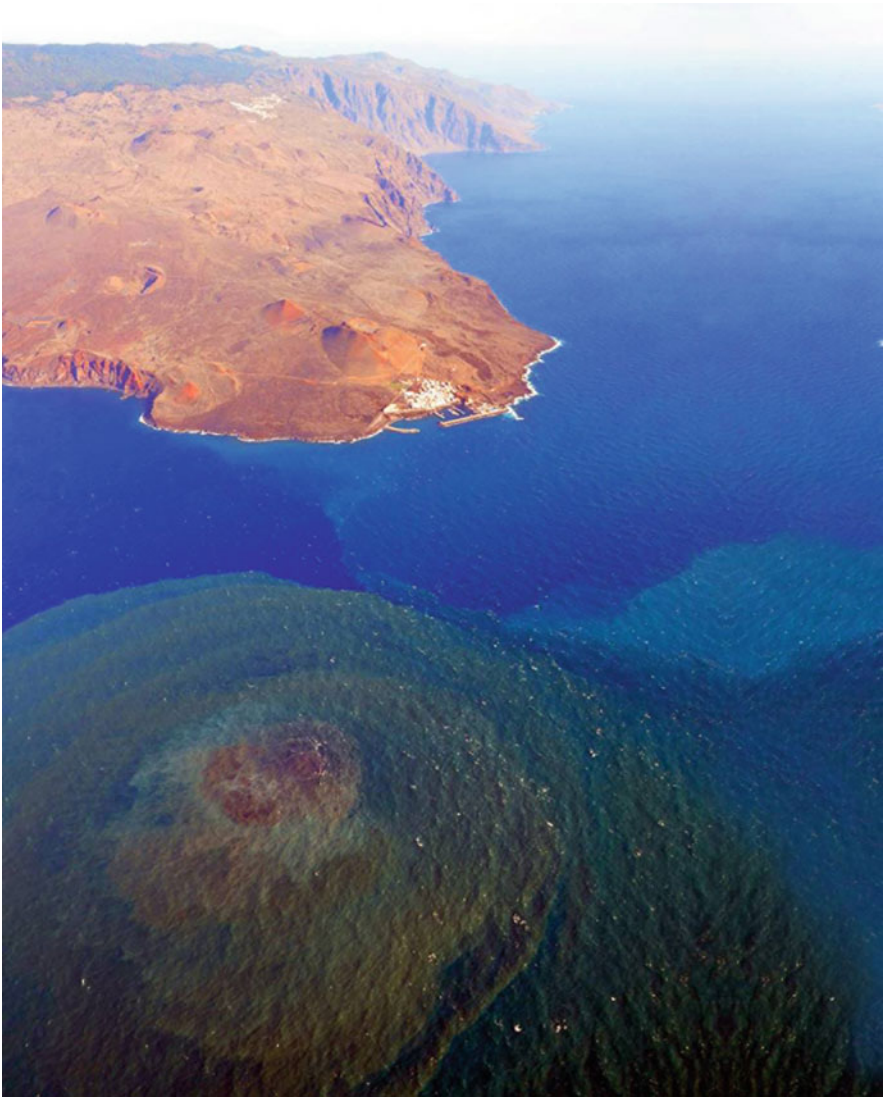

Fig. 24.1 Tagoro volcano eruption in La Restinga coast, 2011. (Photo: Antonio Márquez, Instituto Volcanológico de Canarias (INVOLCAN))

et al., 2020). In the case of the IANP, kelp forests[2] have disappeared in recent decades for causes still unclear, although recent evidence suggests that their failure

[2]The main foundation species of kelp forest in NW Spain are *Laminaria ochroleuca* and *Laminaria hyperborea* (Pérez-Ruzafa et al., 2003).

to recover is possibly due to increasing herbivory pressure.[3] The consequences of the loss of these kelp forests for coastal ecosystem services have remained unassessed, and one of the significant challenges of any assessment is the lack of long-term data sets. In this regard, we assumed in this study that fishers often know far more about the locations of critical habitats and the distribution of marine resources than scientists do (Johannes et al., 2000). Therefore, older fishers and seaweed harvesters are an asset to map past and present distributions of kelp forests, the central fisheries linked with this habitat, and any displacement of fisheries linked to the disappearance of kelp.

In both contexts, we assumed that stakeholder involvement is a source of useful information for scientists and decision-makers and considered community-based management's role in strengthening conservation and management initiatives. Small-scale fishers' knowledge of seasonal variations in marine fish behavior and movements, marine habitat composition changes, and stock assessment (Brown et al., 2018; Johannes et al., 2000; Teixeira et al., 2013) can potentially improve marine governance and monitoring in the face of environmental uncertainty. Furthermore, how this uncertainty is handled "with the people" can influence the perception that local people share (Chuenpagdee et al., 2020; Jentoft et al., 2010) in marine governance and monitoring initiatives, besides potentially increasing their compliance with the norms if these are the result of rules they have collaborated to develop. In sum, we consider that small-scale fishers' collaboration and short- and long-term environmental monitoring are essential for studying environmental change and marine resource recovery after environmental disturbances.

2 Methods

Between 2018 and 2020, a multidisciplinary research team researched El Hierro and Galicia (see Fig. 24.2) within the framework of various collaborative and local stakeholder-centered research projects. Most of the Spanish small-scale fisheries fleets are in Galicia (57.37%), Andalucía (12.85%), and the Canary Islands (9.88%) (Pascual-Fernández et al., 2020a, b). In El Hierro, fieldwork was mainly conducted in La Restinga's population, the main fishing village, and the home of the only *cofradía* on the island. Throughout the year, fishers use the same gear and boats to combine benthic and demersal fisheries, e.g., parrotfish (*Sparisoma cretense*) and alfonsino (*Beryx splendens*), with pelagic oceanic fisheries, mainly tuna.

In the case of the IANP in Galicia, fishing is mostly conducted by fishers from three *cofradías* (Vigo, Cangas, Baiona) located in Ría de Vigo, the southernmost ría

[3] The reasons for this phenomenon are currently being studied within the framework of the project HERBIKELP financially supported by Biodiversity Foundation of the Ministry for Ecological Transition and Demographic Challenge (Spain) to 2021, and results have published during 2022 (Barrientos et al. 2022a, b).

Fig. 24.2 Study areas around the two North Atlantic Spanish MPAs

of Galicia, as well as by fishers from another *cofradía* further away (Bueu; Ría de Pontevedra). For various logistical reasons, only fishers from Cangas participated[4] in this research, and these are stakeholders who usually fish within the IANP year-round, trapping several fish and shellfish species on the seaweed-beds with small traps. Spider crab (*Maja brachydactyla*), octopus (*Octopus vulgaris*), and velvet swimming crab (*Necora puber*) are the most profitable fisheries of the area, being Galicia the most popular region in Spain in terms of octopuses' landings (Pascual-Fernández et al. 2020a, b).

In both case studies, the first step was a mapping exercise with key informants, chosen by their relation to the fishing area and the MPA, and this led to the formulation of general maps representing the seascape of each area – see an example in Fig. 24.5. Specifically, semi-structured *face-to-face* interviews were held in El Hierro with retired fishers and MR employees involved in surveillance tasks. In Galicia, local scientists, and divers with knowledge of the kelp areas and who had been working around the IANP for a long time were interviewed. A second interview-phase was carried out from a non-probabilistic sampling approach, combining semi-structured *face-to-face* interviews on a written questionnaire completed

[4] At this stage, we only have few interviews, and from one *cofradía* due to the COVID pandemic, thus these are preliminary results, and more interviews are expected.

by the interviewer and a draft-mapping to be drawn by each participant. Each interview (0.45–1.5 h) started with an introduction to the topic, followed by a nautical chart orientation.

In La Restinga, we wanted to know if fishers had returned to their traditional grounds, if they fished in the same way, and how they perceived the Sea of Calms' status five years after the total fishing ban; so, questions were divided into four different sections in the questionnaire. The first part included basic questions about the fishing productive unit organization (e.g., number of boats and crew) and the characteristics of their main activities (e.g., central fisheries and fishing traps, fishing distance, and depth-range). The second part included questions about the level of use of the MR, with inquiries about the time of fishing in the buffer zone and fisheries associated with the MR, among others. A third part comprised the main operational cost of the general fishing activity, and finally, the questionnaire included some questions about changes suffered after the volcano's eruption and the fishers' perception about the level of fishing recovery. The questionnaire was useful to obtain additional information about fishers' beliefs about the MR's role in this process. In this study area, we identified 25 small-scale fishing productive units (Pascual-Fernández, 1991) working regularly and authorized to fish inside the MR. Considering some differences among the fishing productive units (e.g., fishing experience, boat length, and crew size), we tried to cover different profiles choosing the interviewers with the help of the *cofradía* and its President. Finally, all participants ($n = 13$) were asked to mark on the map the areas where they regularly fished, considering their main target species.

In Galicia, we wanted to detect long-term changes in kelp forest areas and fisheries associated with this habitat using a questionnaire, which was also divided into different sections. The first part included basic questions about Cangas fishermen's main fishing activity, identifying if this activity included seaweed harvesting and, in the case of just fishing, if the activity was carried out in kelp forest areas. A second part included questions about their general small-scale fishing activity and target species on kelp forests, changes detected in the kelp forests (both on target species and kelps), their perception about these changes, and how changes had affected their activity. Specifically, fishers were asked about the presence and increase of some fish species (*Sarpa salpa*) that may be responsible for the *herbivorism* pressure on kelps. Finally, we asked about the specific fishing areas in both National Park and inner Ría de Vigo, target species, and the presence/absence of kelp forest in those areas. The latter are those areas being studied as part of the HERBIKELP project.

In Cangas, participants ($n = 10$) were asked to mark on the map the areas where they fished, the location of kelp forests, and sites where kelp have disappeared. The *cofradía* had a critical facilitating role in identifying the most experienced fishers that usually work on kelp forest areas. Two fishing units that harvest seaweeds (*Laminaria ochroleuca* and *L. hyperborea*) in Ría de Vigo were extensively interviewed. Besides, small-scale fishers (n = 8) who harvest target species associated with these kelp forests in Ría de Vigo and IANP were likewise interviewed.

The purposive sampling of fishers and local users at each area seemed adequate to generate a map incorporating LEK with the help of members of each *cofradía*. In both case studies, a nautical chart 1:42000-scale of the study area was provided to participants and fine-tipped colored pens to mark local information regarding the change in marine ecosystems, pictures, and bathymetric maps. Finally, additional actions were performed such as boat trips with fishers along the drawn coast in La Restinga, visiting different fishing areas and critical grounds along the Sea of Calms, and diving surveys to assess the status of kelp forest areas within and outside the IANP in Galicia (Ría de Vigo).

Map produced by fishers (see Fig. 24.3) and information provided during the questionnaire-led interviews were digitized and georeferenced into a GIS using a polygon, line, or point shape files as needed with the help of QGIS 3.16-Hannover. Digitized LEK maps were combined into a single map to visualize similarities and differences in participants' spatial information. Concerning La Restinga fishing areas, a final map with an amalgamation of the most frequently occurring classifications through the union of individual LEK maps followed by a count of individual data points where the overlapping layers intersected was made. Key informants and stakeholders reviewed final maps to ensure that all information had been correctly digitized.

3 Results

3.1 Monitoring the Small-Scale Fisheries Areas and Fishers' Behavior After a Submarine Volcano Eruption

From the information gathered jointly with fishers, we produced a set of maps of La Restinga and the Sea of Calms representing the main small-scale fishing areas and fishing grounds, taking into consideration the combination of multiple fisheries, the transition from inshore to deep-water fisheries in the studied area, and the differences within the local small-scale fishing group. Maps show how fishers have come back to their main fishing area around the MR and the Sea of Calms and distribute various small-scale fisheries around the MR and the volcano eruption area, including their traditional fisheries (see Fig. 24.4). According to the questionnaire results, fishers interviewed recognized hand-line fishing gear usage in general (97.7%). After the submarine eruption, most fishers affirmed that the MR and the temporary fishing closure helped recover the fisheries, mainly parrotfish (*Sparisoma cretense*). This map also highlights the diversity of the small-scale fishing activities concentrated on the MR's buffer zones, on the edges of the no-take zone, and in the shallowest areas. Besides, Fig. 24.4 reflects the concentration of the shrimp traps around the volcano. This fishery is in the same area where it was conducted before the catastrophe, revealing the fishing usage recovery level in the area closest to the eruption, even though fishers who fish for shrimp talked about some bottom instability in the area.

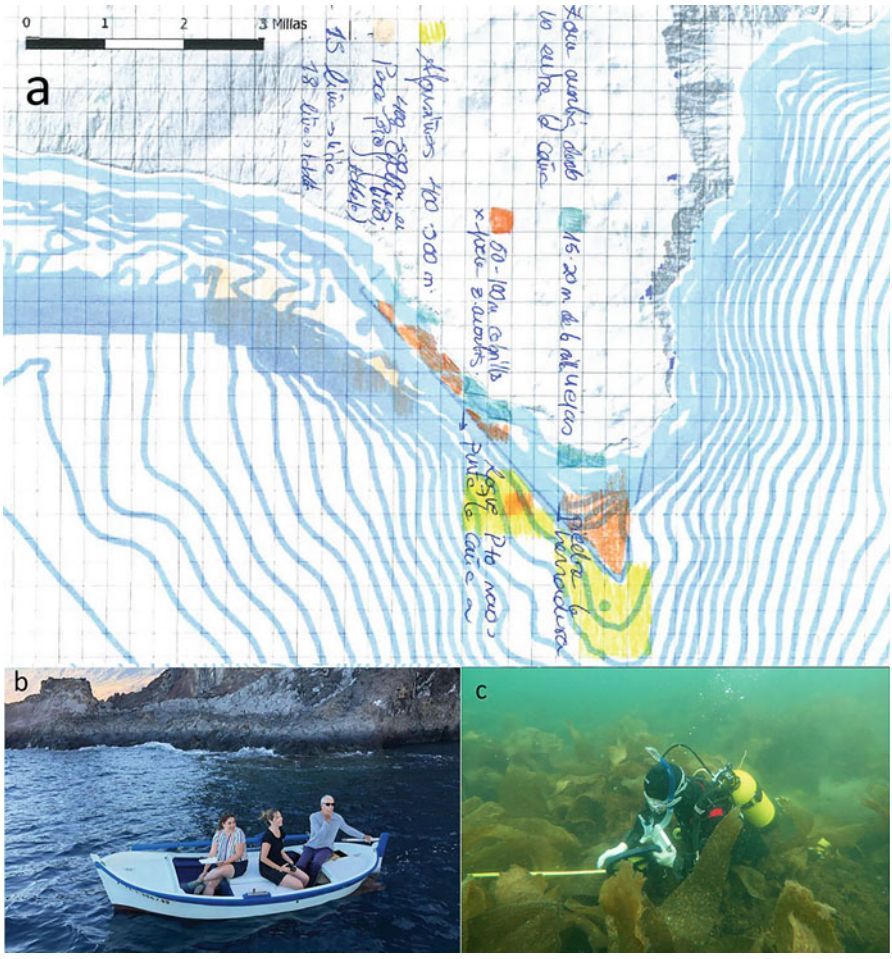

Fig. 24.3 Example of participatory maps results (**a**) and complementary activities carried out in El Hierro (**b**) and Galicia (**c**). (Source: Authors)

Finally, Fig. 24.5 compares fishing strategies for small-scale fishers using boats <10 meters in length and between fishers with wildly different experience levels. These maps revealed essential differences in fishers' behavior, preferences, and ability to access the various fishing grounds, linked to their experience and ecological knowledge, and not by the volcano eruption effects. We found that the most experienced fishers (e.g., boat 3, 6, 5, 9 in Fig. 24.5) could access far away fishing grounds, even when fishing alone in small boats. These experienced and old fishermen were specialized in costly but profitable fisheries such as the blacktail scomber (*Serranus atricauda*) and fisheries over 300 and 700 meters and more in-depth, as alfonsino (*Beryx decadactylus*), stout beardfish (*Polymixia nobilis*),

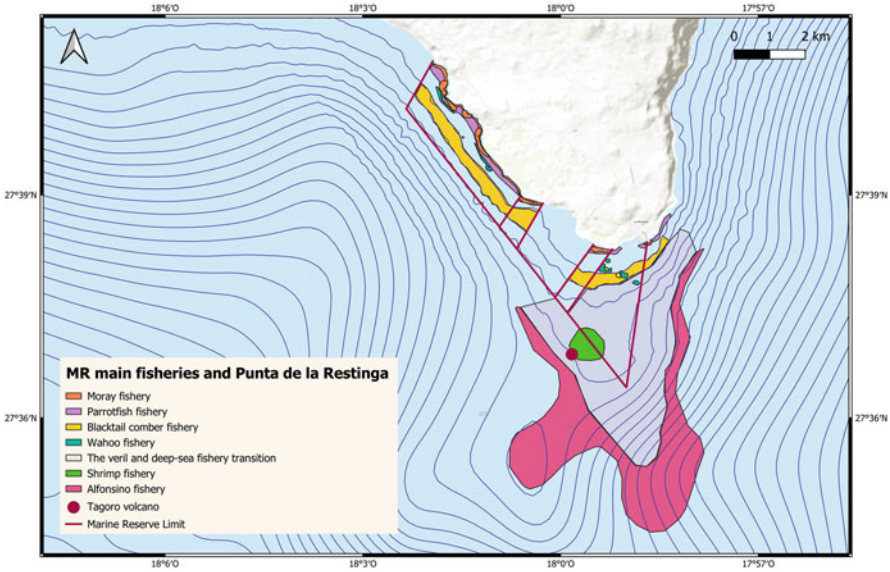

Fig. 24.4 MR main fisheries at Punta de La Restinga

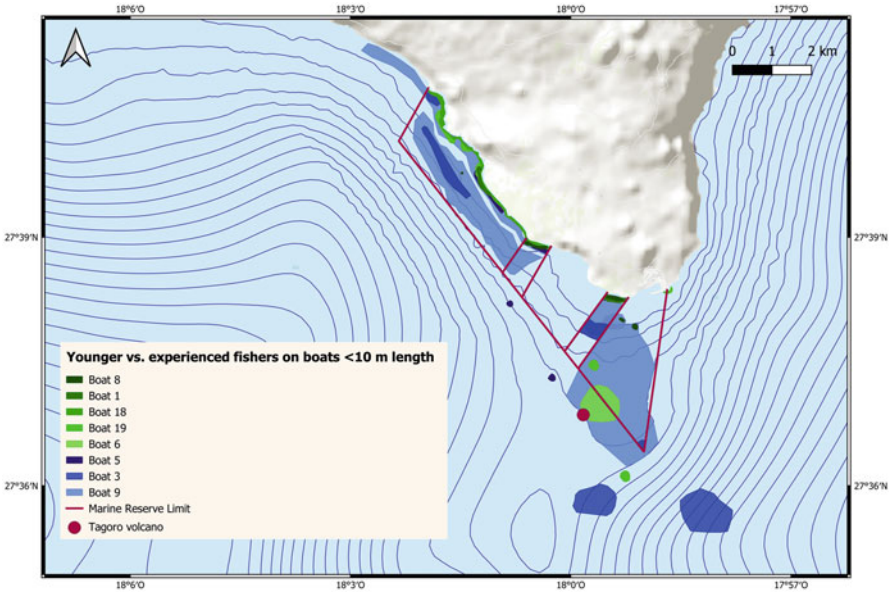

Fig. 24.5 Younger vs. experienced fishers on boats <10 m length at La Restinga fishing village

and oilfish (*Ruvettus pretiosus*) among other targeted species. Variability in LEK was high between experienced and younger fishers, and the inclusion of younger fishers without adequate knowledge may influence fishing strategies around the Sea of Calms. Maps revealed that less experienced fishers (e.g., boats 1 and 8 in Fig. 24.5) might choose simple, effective, low-cost, and practical solutions and strategies to reduce uncertainty by concentrating their fishing efforts on benthic communities closer to shore and the MR.

3.2 *Integrating Fisher Folk Knowledge to Assess Kelp Forest Loss*

In Galicia, data obtained in this first collaborative-study with small-scale fishers in Ría de Vigo-IANP allowed the construction of an initial set of maps showing the main areas where kelp forests have disappeared and where they are still present (Fig. 24.6), as the most relevant fisheries linked to these habitats (Fig. 24.7).

All interviewed fishers agreed that the species *Laminaria ochroleuca* and *L. hyperborea* have disappeared in recent decades, and most of them pointed out their loss in the coastline of the IANP and the outermost areas of Ría de Vigo. At the same time, all agreed that kelp forests are still present inside the Ría de Vigo and some IANP areas. Working with local fishers, we were able to identify where kelp forests are still present: four areas in the northern side of the Ría (From Rande to

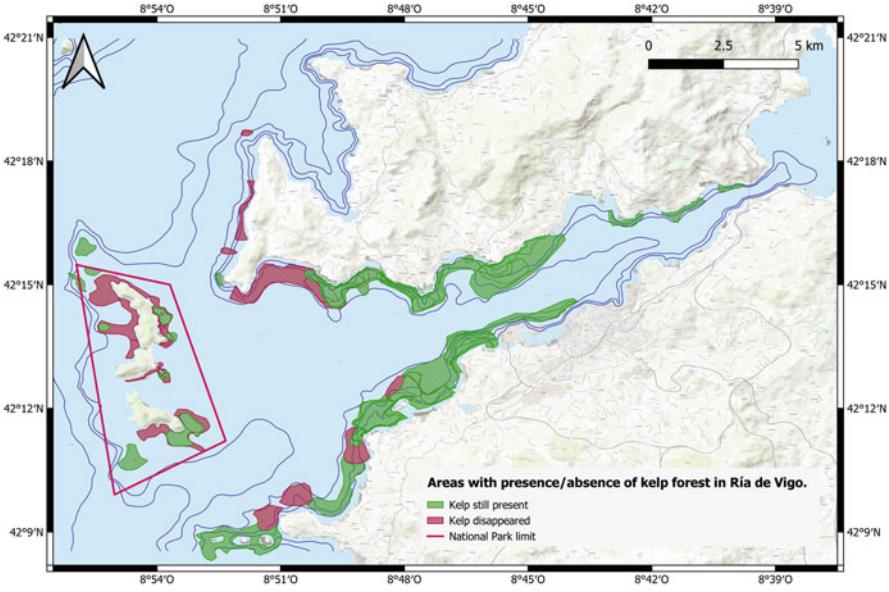

Fig. 24.6 Different areas with presence and absence of kelp forest in Ría de Vigo

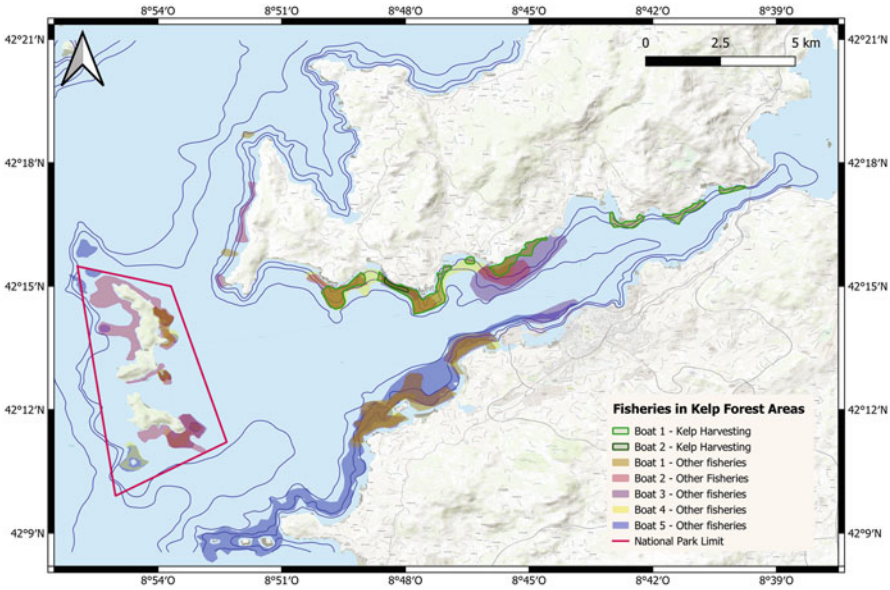

Fig. 24.7 Different Small-scale fisheries linked to kelp forests

Nerga beach), three on the southern side (from Vigo to Estai Cape), and nine small areas in the IANP (Fig. 24.6). On the other hand, fishers highlighted a loss of kelp from most of the IANP shore, from four small areas in the southern side of the Ría (north of Toralla, south of Estai Cape and Punta Meda), and four sites on the northern side (between Nerga and Home Cape).

Results allowed identifying the principal fisheries associated with kelp forest in this region for the first time, highlighting the octopus, spider crab, velvet swimming crab, or the European lobster (*Homarus gammarus*) as the most important commercial fisheries in this Ría. Fishers also identified fishes such as the white seabream (*Diplodus sargus*) and ballan wrasse (*Labrus bergylta*) as target species linked to kelp forest areas (Fig. 24.7). Fishing areas shown by fishers for these species were always the same, only changing the fishing period and the fishing gear. Parallel to kelp retreat, fishers perceived changes in their central fisheries, and many described a decrease in catches in areas where *L. ochroleuca* and *L. hyperborea* have disappeared. The presence of other canopy-forming species, such as the annual *Saccorhiza polyschides* or the pseudo-perennial fucoids *Gongolaria baccata* and *G. usneoides,* could explain why these fisheries have not wholly disappeared from these areas. Finally, both fishers and seaweed collectors agreed on an increase in Sarpa salpa catches in the last decades, supporting the idea that *herbivorism* could be behind the non-recovery of kelps around the IANP.

In Galicia, this is the first-time that fishers' knowledge is used to assess long-term kelp changes in forests and target species. Understanding the link between the kelp forest loss and fishing activities changes is essential to develop better management

practices on these socio-ecological resources on which small-scale fisheries depend. In this regard, our results represent a first step to increase the scientific knowledge about the loss of kelp forests in Galicia considering a major scale than specific areas that are typically studied in ecological research. It also shows how this loss is linked to changes in associated fisheries, affecting the local small-scale fleet.

4 Discussion and Conclusions

During the last decade, social and marine sciences have paid increasing attention to global marine environmental changes and their consequences on small-scale fisheries that have increased their vulnerability and economic uncertainty (Kolding & van Zwieten, 2014). In this context, the general absence of long-term data sets even in a European context represents a serious issue, and some authors have argued for the need to incorporate small-scale fishers' knowledge and science for better policy recommendations, both in terms of fisheries optimization and resource conservation (Kolding & van Zwieten, 2014). LEK represents a suitable and cost-efficient approach for small-scale fisheries when conventional sampling methods are difficult or expensive to implement. Using fishers' knowledge, combining quantitative and qualitative tools can allow for ways to design and implement natural resources management and conservation policies locally (Aswani, 2019) under the increasing global change.

Fishers have detailed knowledge of their resource's environment and their fishing practices (Neis et al., 1999). This approach's benefits extend beyond filling gaps in scientific knowledge, promoting fishers' confidence and engagement with research activities linked with the conservation and monitoring of MPAs. Working together on building common objectives (Chuenpagdee et al., 2020) and sharing perceptions and information about the environmental and economic problems among stakeholders may be an agreed better approach for lasting solutions (Kolding & van Zwieten, 2014). Diversity in ecosystems and local cultures makes it difficult to develop a standardized method to use LEK. However, triangulation with other data sources and comparative techniques can strengthen research results, including the collaboration between researchers with interdisciplinary backgrounds and specialists in social and ecological sciences (Mellado et al., 2014).

Small-scale fishing communities often possess a high level of knowledge regarding fish populations and marine ecology (Scholz et al., 2004). For example, in Galicia, results agree with previous studies that showed a retreat of kelp species in Galicia (Barrientos et al., 2020). In La Restinga, our study reinforced the no-take zone's value in the recovery of small-scale fisheries after the volcano was pointed out (Mendoza et al., 2020), such as the recovery of some target species as *S. Cretense*. In this regard, our study exemplifies the high reliability of small-scale fisher's information and its value facing the challenges of ecosystem management in subtropical and temperate regions that are especially vulnerable to changes due to disasters or global warming, such as the increasing warm-affinity species (Vergés &

Campbell, 2020). The body of information held by fishers has a vital role in fisheries and benthic communities' assessment. Our research results support the research methodology and highlight the interdisciplinary approach's success and suitability in both case studies. Nevertheless, going one step further, when the information is built jointly with fishers it remains consistent and the uncertainty is reduced, turning the scientific research and assessments more convincing to these resource users (Neis et al., 1999) and local communities. For all the above reasons, the integration of LEK in a European marine management context, considering its variations among fishing groups and its role in maintaining traditional small-scale fisheries, seems a good and reliable source of information for assessing and monitoring marine environmental sustainability.

Acknowledgments This study was partially funded by Cajacanarias Foundation and Fundación Bancaria "La Caixa'' through the "Proyecto para el fortalecimiento de la capacidad de adaptación y recuperación en la población de La Restinga (El Hierro, Islas Canarias)" [2017REC23] carried out with research funds from the CajaCanarias Foundation and the La Caixa Banking Foundation. RDLCM was also partially funded by Ramón Areces Foundation through the XVII Call for Social Research Grant, founding reference "CISP17A5887". JPF would also like to acknowledge providing complementary fisheries data to the Macarofood project (Interreg-MAC/2.3d/015), with the European Regional Development Fund's support, as the European Project FoodE funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 862663. The Biodiversity Foundation of the Ministry for Ecological Transition and Demographic Challenge (Spain) supported research activities in Galicia. BioCost Research Group acknowledges funding from Xunta de Galicia within the program "Axudas para a consolidación e estructuración de unidades de investigación competitivas do SUG" (grants ED431D 2017/2020, ED431B 2018/49). SB received funding from the Xunta de Galicia and the European Union (European Social Found - ESF). CPC received financial support from Xunta de Galicia "Axudas de apoio á etapa de formación posdoutoral" (grant ED481B-2021/095). Finally, the authors acknowledge the small-scale fishers' collaboration during this research, as their *cofradías* and the MPA's responsible in both study areas. RDLCM would also express her personal thanks to Inés Chinea Mederos and to Nemesio Pérez.

References

Aswani, S. (2019). Perspectives in coastal human ecology (CHE) for marine conservation. *Biological Conservation, 236*, 223–235.

Aswani, S., & Lauer, M. (2006). Incorporating fishermen's local knowledge and behavior into geographical information systems (GIS) for designing marine protected areas in Oceania. *Human Organization, 65*, 81–102.

Barrientos, S., Barreiro, R., Cremades, J., & Pineiro-Corbeira, C. (2020). Setting the basis for a long-term monitoring network of intertidal seaweed assemblages in Northwest Spain. *Marine Environmental Research, 160*, 105039.

Barrientos, S., Piñeiro-Corbeira, C., & Barreiro, R. (2022a). Temperate kelp forest collapse by fish herbivory: A detailed demographic study. *Frontiers in Marine Science, 9*.

Barrientos, S., Barreiro, R., & Piñeiro-Corbeira, C. (2022b). Paradoxical failure of *Laminaria ochroleuca* (Laminariales, Phaeophyceae) to consolidate a kelp forest inside a Marine National Park. European Journal of Phycology [In press].

Bavinck, M., Jentoft, S., Pascual-Fernández, J. J., & Marciniak, B. (2015). Interactive coastal governance: The role of pre-modern fisher organizations in improving governability. *Ocean and Coastal Management, 117*, 52–60.

Brown, M. I., Pearce, T., Leon, J., Sidle, R., & Wilson, R. (2018). Using remote sensing and traditional ecological knowledge (TEK) to understand mangrove change on the Maroochy River, Queensland, Australia. *Applied Geography, 94*, 71–83.

Burns, P., Hawkins, J., & Roberts, C. (2020). Reconstructing the history of ocean wildlife around Ascension Island. *Aquatic Conservation: Marine and Freshwater Ecosystems, 30*, 1220–1237.

Chuenpagdee, R., de la Cruz-Modino, R., Barragán-Paladines, M. J., Glikman, J. A., Fraga, J., Jentoft, S., & Pascual-Fernández, J. J. (2020). Governing from images: Marine protected areas as case illustrations. *Journal for Nature Conservation, 53*, 125756.

Davies, K., Murchie, A. A., Kerr, V., & Lundquist, C. (2018). The evolution of marine protected area planning in Aotearoa New Zealand: Reflections on participation and process. *Marine Policy, 93*, 113–127.

De la Cruz Modino, R. (2012). *Turismo, pesca y gestión de recursos. Aportaciones desde La Restinga y L'Estartit*. Ministerio de Educación, Cultura y Deporte.

De la Cruz Modino, R., & Pascual-Fernández, J. J. (2013). Marine protected areas in the Canary Islands – Improving their governability. In M. Bavinck, R. Chuenpagdee, S. Jentoft, & J. Kooiman (Eds.), *Governability of fisheries and aquaculture: Theory and applications* (pp. 219–240). Springer.

Frangoudes, K., Marugán-Pintos, B., & Pascual-Fernández, J. J. (2008). From open access to co-governance and conservation: The case of women shellfish collectors in Galicia (Spain). *Marine Policy, 32*, 223–232.

Gerhardinger, L. C., Godoy, E. A. S., & Jones, P. J. S. (2009). Local ecological knowledge and the management of marine protected areas in Brazil. *Ocean and Coastal Management, 52*, 154–165.

Higgins, R. M., Vandeperre, F., Pérez-Ruzafa, A., & Santos, R. S. (2008). Priorities for fisheries in marine protected area design and management: Implications for artisanal-type fisheries as found in southern Europe. *Journal for Nature Conservation, 16*, 222–233.

Jentoft, S., Chuenpagdee, R., Bundy, A., & Mahon, R. (2010). Pyramids and roses: Alternative images for the governance of fisheries systems. *Marine Policy, 34*, 1315–1321.

Jentoft, S., Chuenpagdee, R., & Pascual-Fernández, J. J. (2011). What are MPAs for: On goal formation and displacement. *Ocean and Coastal Management, 54*, 75–83.

Jentoft, S., Pascual-Fernández, J. J., De la Cruz Modino, R., Gonzalez-Ramallal, M., & Chuenpagdee, R. (2012). What stakeholders think about marine protected areas: Case studies from Spain. *Human Ecology, 40*, 185–197.

Johannes, R. E., Freeman, M. M. R., & Hamilton, R. J. (2000). Ignore fishers' knowledge and miss the boat. *Fish and Fisheries, 1*, 257–271.

Kolding, J., & van Zwieten, P. (2014). Sustainable fishing of inland waters. *Journal of Limnology, 73*, 132–148.

Mellado, T., Brochier, T., Timor, J., & Vitancurt, J. (2014). Use of local knowledge in marine protected area management. *Marine Policy, 44*, 390–396.

Mendoza, J. C., Clemente, S., & Hernández, J. C. (2020). Modeling the role of marine protected areas on the recovery of shallow rocky reef ecosystems after a catastrophic submarine volcanic eruption. *Marine Environmental Research, 155*(5), 104877.

Neis, B., Schneider, D. C., Felt, L., Haedrich, R. L., Fischer, J., & Hutchings, J. A. (1999). Fisheries assessment: What can be learned from interviewing resource users? *Canadian Journal of Fisheries and Aquatic Sciences, 56*, 1949–1963.

Pascual-Fernández, J. (1991). *Entre el mar y la tierra. Los pescadores artesanales canarios*. Ministerio de Cultura - Interinsular Canaria.

Pascual-Fernández, J. (1999). The share system in fishing. *Europaea, 5*, 65–87.

Pascual-Fernández, J. J., De la Cruz Modino, R., Chuenpagdee, R., & Jentoft, S. (2018). Synergy as strategy: Learning from La Restinga, Canary Islands. *Maritime Studies, 17*, 85–99.

Pascual-Fernández, J. J., Florido-del-Corral, D., De la Cruz-Modino, R., & Villasante, S. (2020a). Small-scale fisheries in Spain: Diversity and challenges. In J. J. Pascual-Fernández, C. Pita, & M. Bavinck (Eds.), *Small-scale fisheries in Europe: Status* (pp. 253–281). Resilience and Governance. Springer International Publishing.

Pascual-Fernández, J. J., Pita, C., & Bavinck, M. (Eds.). (2020b). *Small-scale fisheries in Europe: Status, resilience and governance*. Springer.

Perez de Oliveira, L. (2013). Fishers as advocates of marine protected areas: A case study from Galicia (NW Spain). *Marine Policy, 41*, 95–102.

Pérez-Ruzafa, I., Izquierdo, J. L., Arújo, R., Sousa-Pinto, I., Pereira, L., & Bárbara, I. (2003). Mapas de distribución de algas marinas de la Península Ibérica e Islas Baleares. XVII. *Botánica complutensis, 27*, 155–164.

Roncin, N., Alban, F., Charbonnel, E., Crec'hriou, R., de la Cruz Modino, R., Culioli, J.-M., Dimech, M., Goñi, R., Guala, I., Higgins, R., Lavisse, E., Direach, L. L., Luna, B., Marcos, C., Maynou, F., Pascual, J., Person, J., Smith, P., Stobart, B., … Boncoeur, J. (2008). Uses of ecosystem services provided by MPAs: How much do they impact the local economy? A southern Europe perspective. *Journal for Nature Conservation, 16*(4), 256–270.

Scholz, A., Bonzon, K., Fujita, R., Benjamin, N., Woodling, N., Black, P., & Steinback, C. (2004). Participatory socio-economic analysis: Drawing on fishermen's knowledge for marine protected area planning in California. *Marine Policy, 28*, 335–349.

Silvano, R. A., & Begossi, A. (2012). Fishermen's local ecological knowledge on Southeastern Brazilian coastal fishes: Contributions to research, conservation, and management. *Neotropical Ichthyology, 10*, 133–147.

Teixeira, J. B., Martins, A. S., Pinheiro, H. T., Secchin, N. A., Leão de Moura, R., & Bastos, A. C. (2013). Traditional ecological knowledge and the mapping of benthic marine habitats. *Journal of Environmental Management, 115*, 241–250.

Vergés, A., & Campbell, A. H. (2020). Kelp forests. *Current Biology, 30*, R919–R920.