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Dipartimento Scienze Vita e Ambiente

PhD Thesis

"Ecosystem-based management approaches applied to Mediterranean Marine Protected Areas (MPAs): a holistic strategy of governance, ecological assessments and conservation planning in order to inform sound management of marine resources"

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PhD Thesis Summary

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Summary

Ecosystem-based management aims to provide a mechanism for achieving a consensus among multi-sectorial activities for sustaining goods and services and achieving ecological, economic and social objectives in an area. The present study adopts innovative methods and approaches aiming to promote a holistic approach towards collaboration and effective conservation management in Mediterranean Marine Protected Areas (MPAs). In order to understand the current management needs in the Mediterranean MPAs, a management effectiveness evaluation was conducted in the Mediterranean scale following an existing guide (Tempesta and Otero, 2013). Information was collected through a synthesis and integration of different approaches during the period 2013-2014, and MPA management was evaluated on the basis of 21 indicators that described the general categories: (i) management and legislation; (ii) conservation features; (iii) pressures; (iv) communication and outreach. Case studies were initially assessed separately and were finally compared in order to identify common challenges and good practices in MPA management that may be put forward. Some of the most important problems were the inadequate annual funding; limited surveillance and law enforcement; the inadequate stakeholder engagement and bottom-up approaches; policy gaps and long bureaucratic processes to take action; inadequate monitoring of ecological and socio-economic parameters; limited understanding of human activity threats and impacts along with defining critical thresholds that may assure good environmental status of marine ecosystems. We highly recommend that the evaluation be a cyclic process conducted by a neutral practitioner that will

inform management decisions and that results should be disseminated in order to reach a high status of MPA management performance in the Mediterranean.

The evaluation of MPA management effectiveness guided the next steps of the study towards addressing realistic MPA needs and providing suggestions to improve MPA management. We focused at Portofino MPA case study (Ligurian Sea, Italy) - the third smallest MPA in Italy hosting rich marine biodiversity and a significant amount of human activities. One of the future targets of the MPA's consortium is to expand its area in order to improve its capacity to effectively protect vulnerable habitats and the species it hosts. Taking into account the past experience and the inadequate communication and up-to-date information in the area, this initiative is expected to raise conflicts and opposition from users. Hence, Portofino MPA represents a case study of particular interest and relevance with MPAs facing similar issues.

Following a holistic methodological approach, an engagement process was carefully designed to provide an insight into the social networks' characteristics directly involved in supporting stakeholder engagement for sound governance performance and co-management of resources. Enhancing stakeholder engagement from the beginning of the process is essential in order to holistically inform decisions and increase the efficiency of conservation management. It is widely accepted that stakeholder engagement may promote cooperation and the exploration of possible solutions to common problems; facilitate the mitigation of conflicts due to various interests; and enhance coordination and the enforcement of common rules in a more transparent way.

A framework to examine structural patterns in social networks and identify central actors with the capacity to serve as communication hubs is suggested to boost information flow and enhance stakeholder participation in decision-making. The approach consists of two powerful tools, Stakeholder Analysis and Social Network Analysis, that their capacity to provide an in-depth knowledge of the complexity of social-ecological systems and the factors that influence the engagement process in MPA management has been recently identified. Identification of stakeholders and their relations in a social network, where information exchange and interaction occurs, may highlight important channels for communication, or indicate key stakeholders with the power to control information flow and influence perceptions. This information may be leveraged to accelerate behaviour, facilitate bridging between organisations, promote deliberation, and improve the diffusion of information in MPA management. The outcomes of the study showed that the social network of the Portofino MPA exhibits a core-periphery structure where some user groups seem to have more privileges regarding access to information and resources in the area. The core of the network keeps the network together, and central stakeholders have the capacity to act as communication hubs and facilitate a two-way information flow that will foster communication, trust and collective learning in natural resource management. However, more effort should be made towards strengthening relationships between actors that may influence or be influenced by decisions relating to the MPA. The adoption of alternative communication strategies that integrate visualisation and user-friendly web platforms, in parallel to personal communication are suggested to involve more actively marginalized actors into decisions, that will increase the network's cohesion, mitigate the power of central actors and augment plurality and new ideas in the engagement process.

Production and synthesis of quantitative and qualitative information, related to conservation features and human activities, is another important aspect in conservation management that negotiation and decisions will be based on. Management of small scale and recreational fishing is one of the most important concerns and challenges that Marine Protected Areas (MPAs) have to encounter from a socio-economic, cultural and ecological point of view. Monitoring and assessing fishing activity requires complicated approaches due to the heterogeneity of methods that combine different gears depending on the target species, the season and the characteristics of the area. Many standardized strategies of fisheries management have tried and failed to capture this spatial and temporal heterogeneity, or to provide improved understanding of fishing impacts on the ecosystem components. The present study developed a framework for the monitoring and mapping of recreational and artisanal fishing activity. The framework considers and may be adjusted depending on the MPA management capacity in terms of budget and technology available, personnel available, the level of trust that characterizes the relationship between the MPA and the fishermen, and the willingness of all relevant actors and authorities to provide or collate respectively information. Data from different monitoring strategies and sources were integrated to archive a complete dataset that described different fishing practices in the area. Simple spatial indicators that describe fishing effort were used to map and describe the footprint of each fishing practice on vulnerable habitats, and identify the areas that receive greater fishing pressure.

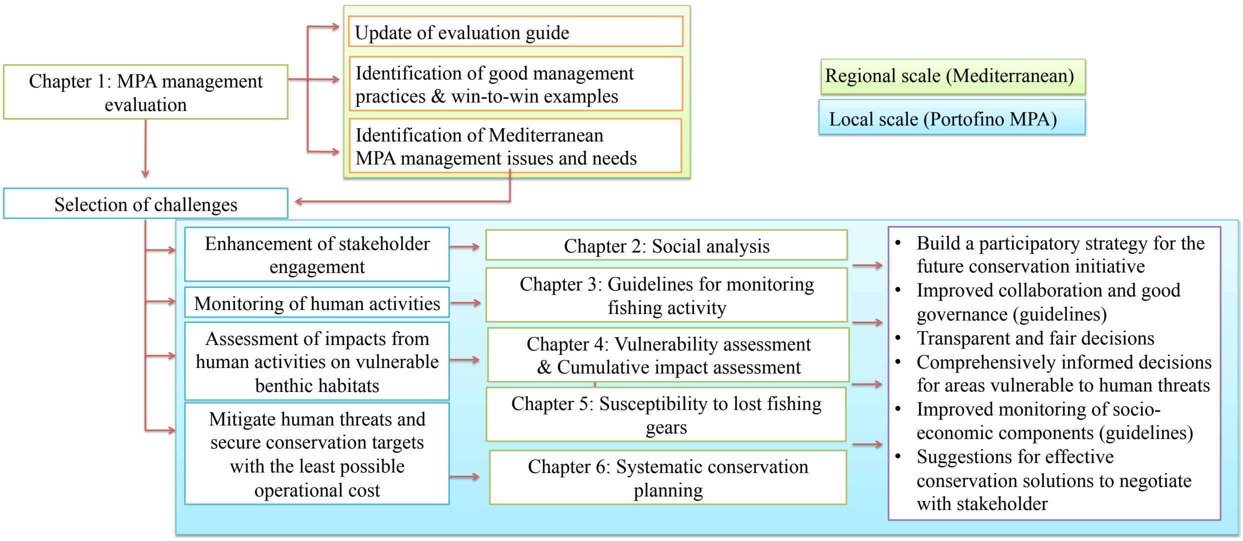
However this is the first step in order to assess the impacts of fishing pressure on vulnerable habitats. Pressure-impact assessments were conducted using spatial analysis in order to holistically inform management decisions on vulnerable habitats such as coralligenous under pressure in Portofino MPA. The approach considers the cumulative impacts caused by different fishing practices and incorporates uncertainty regarding available information following the precautionary principle. Cumulative impacts are based on a conceptual model that identifies the pathways through which activities cause harm and describing the likelihood and consequences of an event. The vulnerability assessment quantifies these causal-chain links between biophysical attributes and to human stressors that are described in the conceptual models. The vulnerability informs on the potential risk of loosing (or degrading) a particular habitat due to a specific pressure, and can provide further support to the assessment of the cumulative impacts caused by different fishing practices operating in an MPA.

Coralligenous communities, in terms of coverage, are more abundant in zone B, while *Posidonia oceanica* meadows dominate in zone C of Portofino MPA. However, a great percentage of the habitat lies outside the MPA borders, which confirms the desire of the MPA management board to expand the area. The areas that receive the highest amount of fishing effort were located between depths of 30-40 m receive the highest fishing pressure at the majority of zone B. The vulnerability assessment revealed that artisanal nets, and both recreational and artisanal bottom longlines, had the highest potential impact on coralligenous habitat, independently from the duration that are active on the seafloor. Other recreational activities that were considered to have high potential impact for coralligenous due to the destructive characteristics of the practice and gear used, or due to the pressure's high intensity and frequency, were vertical jigging, bottom trolling and big game with a rod and reel. The cumulative impact assessment provided an in depth understanding of combined exposure-effect approaches and identified additional areas in zone C and in greater depths, that fishing activity is necessary to be managed more strictly. Several suggestions were enlisted in order to mitigate fishing impacts on coralligenous habitats, for instance the establishment of additional spatial and temporal closures, prohibition of destructive fishing practices, etc. while policy gaps were also identified in the current management system. The approach takes into account the heterogeneity of techniques and captures the different scale of impacts on benthic habitats in a systematic, transparent and repeatable way, and provides a useful tool that integrates ecological, management and policy interventions.

An emerging threat in coastal MPAs is the loss of fishing gears that drift away driven by currents and finally end up on the seafloor covering in some cases a significant amount of fragile benthic habitats like coralligenous. In Portofino MPA this is reported as a common issue and frequently divers retrieve the lost gears and monitor it. To inform the MPA regarding which areas are more susceptible to lost fishing gear, a semi-quantitative spatial analysis was conducted using information from the sea-bottom morphology (depth, slope, Benthic Position Index, rugosity, curvature). The areas identified overlap spatially with areas of high fishing effort, while the local currents agree that most susceptible areas are located in the southern part of Portofino MPA. Although data quality regarding information coming from divers was poor, the suggested analysis may provide useful information in order to focus management actions on specific areas.

Finally, the Marxan with Zones conservation planning model was applied on Portofino MPA's present zoning plan in order to provide alternative solutions for the enlargement and re-zoning of the MPA. Different scenarios concerning the regulation of human activities such as fishing and diving activities taking place at different zones were developed. In our management plan, we set high level conservation targets based on relative EU Directives, the high conservation status of the Portofino MPA (SPAMI) and management objectives. In the present study preliminary results are shown for a single scenario where a 4-zone plan is suggested to the expanded surface area of the MPA, where diving and fishing activity are re-arranged in space and strictly regulated. The suggested zoning plan provided by MARXAN with Zones ensures that high conservation objectives are reached in Portofino MPA with the lowest possible operational cost.

Overall, the present study aimed to provide a complete ecosystem-based management approach that considers the social and ecological drivers of the system as complementary components for supporting future conservation initiatives towards collaborative management of resources. The management suggestions of this study provide transparent, comprehensive and efficient plans that can improve the governance and the management of marine resources in the area. Innovative tools and methods were integrated to inform several aspects in the management of marine resources in order to promote a holistic approach towards collaboration and deliberation in MPA management. The developed methodology offers guidance on how to structure and focus efforts for collecting, synthesizing and analyzing of necessary information to inform holistically policymaking and management processes. Results provide useful advise in mitigating the cumulative impacts of human activities and deliver alternative solutions that are based on strict systematic conservation planning principles. Moreover, the study may assist the Portofino MPA to build the social conditions and a future engagement strategy where stakeholders will welcome the conservation initiative for its expansion, however particular effort should be made by the MPA management board towards this direction.



Flow chart of the Thesis work flow along with relevant chapters.

Keywords: Ecosystem-based management; ecological assessment; cumulative impacts; conservation planning; Marine Protected Areas

Introduction

The ITN Monitoring of Mediterranean Marine Protected Areas (MMMPA) project has been inspired by the idea of individuals from different fields, such as students, divers, managers and scientists working together towards a common target, the marine conservation. Considering the key role of MPAs in achieving the biodiversity conservation targets and the high discrepancy in the actual management between the existing Mediterranean MPAs, it is pivotal to reinforce them with concrete measures of management and governance capacity (MMMPA, Annex I). The scope of the project has been to shape the profile of the next generation of MPAs scientists and managers in the Mediterranean Sea. The present work is part of Work Package 5 ('Integration and Dissemination') that aims to integrate information resulting from the other WPs under innovative Decision Support Tools (DSTs) in order to holistically inform MPA managers considering the complexity of ecosystems and governance settings (Ostrom, 1990).

Ecosystem Based Management (EBM) aims to provide a mechanism for achieving a consensus among multi-sectorial activities for sustaining goods and services and achieving ecological, economic and social objectives in an area (Pomeroy and Douvere, 2008). To achieve successful stakeholder participation and adaptive co-management of marine resources, two fundamental components of the process should be considered:

(i) <u>The participation and representation of all actors' perspectives and interests influencing or being influenced by decisions (Bodin et al., 2006)</u>

Enhancing stakeholder engagement from the beginning of the process is essential in order to holistically informed decisions and increase the efficiency of conservation management (Ehler and Douvere, 2009). Stakeholder engagement may promote cooperation and the exploration of possible solutions to common problems; facilitate the mitigation of conflicts due to various interests; enhance coordination and the enforcement of common rules in a more transparent way (Markantonatou et al, 2015a, and references therein). Managers must combine social analysis and communication strategies that allow interaction and knowledge sharing between users as the means to achieve successful engagement. This information may highlight important channels for communication, or indicate key stakeholders with power to control the information flow and influence perceptions supporting or opposing the initiative (Prell et al., 2009).

(ii) The provision of adequate information, related to conservation features and human activities, and Decision Support Tools (DSTs) on which decisions will be based on (Markantonatou et al., 2013a)

Production and synthesis of information related to ecosystems and human activities will support mutual understanding between stakeholders, managers and decision makers (Markantonatou et al., 2013a). Monitoring and mapping of human activities such as small scale and recreational fishing, diving and yachting is a challenging process. For instance, monitoring and assessing fishing activity requires complicated approaches to capture the high heterogeneity and combination of gears, the variation of target species and the poor data availability (Freire & García-Allut, 2000). Moreover, integrated approaches are necessary in order to assess human pressures on ecological components such as vulnerable habitats and increase the efficiency of management response (Markantonatou et al., 2014).

The present scientific document aims to provide a holistic ecosystem-based management approach towards sound governance and effective conservation management in Mediterranean MPAs by integrating different Decision Support Tools at multiple levels of management, governance, ecological assessments and conservation planning.

In Chapter 1 an updated guide (after Tempesta and Otero, 2013) for evaluating management effectiveness that integrates and synthesizes information essential to MPA management is provided. The guide may enable managers to prioritize and address issues by setting new targets directly linked to management actions. The comparison between MPAs allows the assessment of the general status of MPAs performance in Mediterranean and promotes the sharing of knowledge and good practices that may improve MPA management (Tempesta and Otero, 2013). Finally the study assisted in understanding the MPA challenges and guided the further focus of the study towards this direction. From this work in total two feedback reports on the results of the assessment were produced (Markantonatou et al., 2013c; 2015e), two publications have been achieved in scientific journals that review of seafloor mapping and cartography, and summarize preliminary results regarding the management in Mediterranean MPAs (Markantonatou et al. 2013b; Meindiger et al., 2013).

The next chapters focus in Portofino MPA case study (Italy) established in 1999, is the third smallest MPA in Italy hosting a rich biodiversity. The relatively small with multiple human activities taking place within the area and the common opposition of users stimulated by conservation decisions (Salmona and Verardi, 2001), makes Portofino MPA representative of a vast majority of the Mediterranean MPAs. Conducted at a time when Portofino MPA considers initiating negotiating plans to expand the reserve, the next chapters are of particular interest and relevance with MPAs facing similar issues. Following a holistic methodological approach, an engagement process was carefully designed and integration of updated and efficient information were used to inform decisions. The management suggestions of this study provide transparent, comprehensive and efficient plans that can improve the governance and the management of marine resources in the area.

More specifically, Chapter 2 aims to provide an insight into the social networks' characteristics directly involved in supporting stakeholder engagement for sound governance performance and co-management of resources (Prell et al., 2009; Borgatti and Everett, 2009). A framework to examine structural patterns in social networks and identify central actors with the capacity to serve as communication hubs is suggested to boost information flow and enhance stakeholder participation in decision-making. The approach consists of two powerful tools that have been very recently identified in resource management, Stakeholder Analysis and Social Network Analysis. Moreover, the use of online communication tools is examined in order to increase engagement and facilitate a two-way information flow that will foster communication, trust and collective learning in Portofino MPA. During this work, for the first time in Portofino MPA a participatory workshop including all stakeholders was conducted, and perceptions from different stakeholder groups were transferred to the MPA management board, trusting that this is a stepping-stone for the future engagement initiative. One report (Sano et al., 2013) was sent as feedback to Portofino MPA's actors and managers, and two scientific publications have been completed. Markantonatou et al. (3013a) reviewed online communication tools ranging from simple dissemination tools such as Social Media and multimedia environments to virtual communication, or sophisticated participatory cartographic and citizen science platforms in order to understand the capacity of these tools in facilitating stakeholder engagement. Markantonatou et al. (2015a,b) employing a social network perspective in exploring the governance conditions and their implications in information flow that drive stakeholder engagement in natural resource management in Portofino MPA. They suggested the adoption of alternative communication strategies that integrate visualisation and user-friendly online platforms to facilitate stakeholder engagement, in parallel to personal communication.

Chapters 3 and 4 provide an integrated approach to assessing the pressures and impacts of human activities such as artisanal and recreational fishing activity on vulnerable habitats through a standardized protocol, in order to support sound management decisions. Guidelines for monitoring and mapping of fishing activity through simple spatial indicators have been suggested to MPA managers by integrating data from different monitoring strategies and tools (Markantonatou et al., 2015c). Ecological assessments, such as cumulative assessments, using spatial analysis were conducted in order to provide updated information on human activities and conservation actions, and inform management decisions on vulnerable habitats under pressure. This approach considers the cumulative impacts caused by different fishing practices and incorporates uncertainty regarding available information following the precautionary principle (Markantonatou et al., 2014).

Chapter 5 presents a semi-quantitative analysis regarding the susceptibility of benthic habitats to lost fishing gear (LFG) was assessed based on sea bottom topography and habitat complexity features as key factors that drive this emerging threat in marine environment. The challenge of this chapter is to produce efficient spatial information on areas that may accumulate LFG using moderate quality of data collected by volunteer divers. However, until now, this is the only low-cost approach that MPAs adopt all over the world in order to monitor and retrieve LFG. The fact that this method is applicable to all coastal MPAs regardless the substrate and habitat types present, makes this work of extreme importance in order to guide targeted monitoring and retrieval of LFG by divers (Markantonatou et al., *in prep*).

Chapter 6 provides flexible conservation solutions in Portofino MPA based on sound scientific knowledge of the habitats and the human pressures exerted on them. Innovative DSTs such as Marxan With Zones are used to suggest the area's expansion and the re-establishment of zoning plans in order to reach conservation objectives with the lowest operational cost. The approach integrates multiple sets of geo-referenced information ranging from critical habitats and endangered species, to morpho-sedimentary features of the seafloor, and fish species of commercial importance (Markantonatou et al., 2015g). The conservation targets inform a range of EU Conventions and Directives and are in line with the MPA's institutional objectives and the local vision. Human activities (diving, fishing, anchoring, mooring) in Portofino MPA were mapped using updated, geo-referenced information collated from the monitoring of the MPA and interviews conducted during the period 2013-2015. With Chapter 6 the EBM approach adopted is complete. The strategy suggested considers the social and ecological drivers of the system as complementary components for supporting future conservation initiatives towards collaborative management of resources.

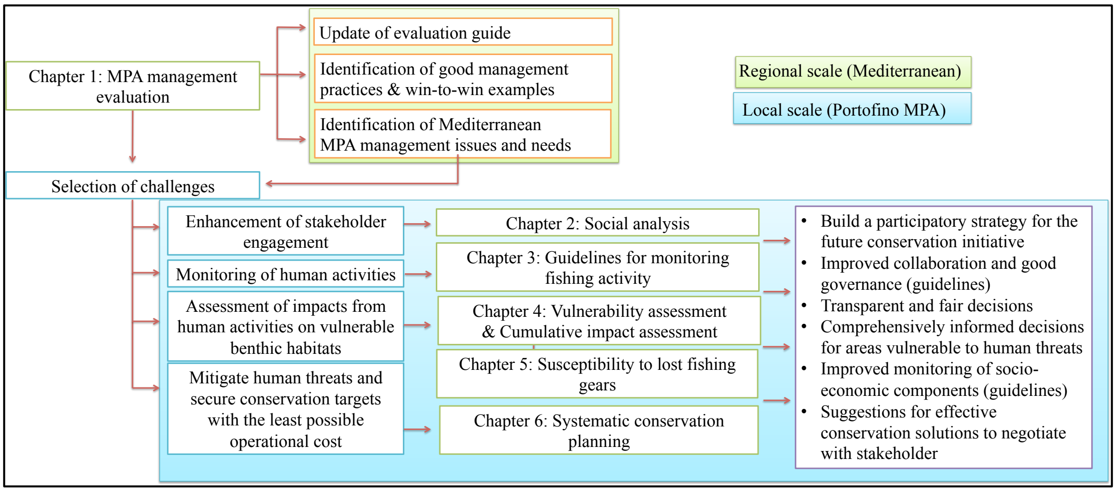


Figure 1: Flow chart of the Thesis work flow along with relevant chapters.

Finally, the present PhD Thesis is closing with Chapter 7 that describes the MMMPA's achievements and social network evolution during the project's lifetime. This work describes how MMMPA fellows were able to catalyse collaborations between them and leading teams for their research activities exploring possible ways to integrate and complete each other and deliver a deep insight to coastal and MPA management. SNA is applied and the comparison of the network during the beginning and finalization of the project illustrates how a group of unconnected individuals and entities have forged relationships and formed a network over the last 3 years. The outcomes of this study provide a novel approach to illustrate the evolution of the MMMPA's social network, and highlights how these connections have led to the success of the project and delivery of the final expected project outputs. This work was presented in the final Conference of MMMPA, has been submitted to the International Conference of CIESM, and further research has been planned in order to suggest this method as tool for measuring integration of multi-disciplinary scientific projects.

References

Bodin, Ö., Crona, B.I., Ernstson, H., 2006. Social networks in natural resource management: what is there to learn from a structural perspective? Ecology and Society 11, r2.[online] URL: http://www.ecologyandsociety.org/vol11/iss2/resp2/

Borgatti, S.P., Everett, M.G., 1999. Models of core/periphery structures. Social Networks 21, 375–395.

Ehler, C., Douvere, F., 2009. Marine Spatial Planning: a step-by-step approach toward ecosystem-based management. Intergovernmental Oceanographic Commission and Man and the Biosphere Programme. IOC Manual and Guides no. 53, ICAM Dossier no.6, Paris: UNESCO

Freire J., Garcia-Allut, A., 2000. Socioeconomic and biological causes of management failures in European artisanal fisheries: the case of Galicia (NW Spain). Mar. Pol., 24 : 375-384.

Markantonatou, V., Noguera-Méndez, P., Semitiel-García, M., Hogg, K., Sano, M., 2015a. Social networks and information flow: building the ground for collaborative marine conservation planning in Portofino Marine Protected Area (MPA). Journal of Ocean and Coastal Management. *In press.*

Markantonatou, V., Noguera-Méndez, P., Semitiel-García, M., Hogg, K., Sano, M., 2015b. Guidelines for increasing information flow and stakeholder engagement in Marine Protected Areas. ITN MMMPA Project Final Deliverable 5.2.4.

Markantonatou, V., Marconi, M., Prato, G., Cappanera, V., Cerrano, C., 2015c. Guidelines for monitoring pressure and impacts from small scale and recreational fishing activity in Mediterranean Marine Protected Areas. ITN MMMPA Project Final Deliverable 5.2.4.

Markantonatou, V., Cerrano, C., 2015d. Guidelines for monitoring MPA management effectiveness in Mediterranean Marine Protected Areas. MMMPA Final Conference.

Markantonatou, V., Cerrano, C., 2015e. Evaluation of MPA management performance in Mediterranean Marine Protected Areas. ITN MMMPA Project Deliverable D.5.2.3.

Markantonatou, V., Milanese, M., Cerrano, C., 2015f. Monitoring collaboration and integration in scientific projects. in: Proceedings MMMPA final conference - CIESM Committee VI (Coastal Ecosystems and Marine Policy) “Mediterranean Marine Protected Areas: Integrated Management as a Response to Ecosystem Threats”, 15-17 October, Ancona, Italy.

Markantonatou, V., Giakoumi, S., Mazor, T., Gianni, F., Zapata P., Cerrano, C., 2015g. Conservation planning in Portofino MPA. ITN MMMPA Project Final Deliverable D.5.2.4.

Markantonatou, V., Marconi, M., Cappanera, V., Cambodonico, P., Bavestrello, A., Cattaneo- Vietti, R., Papadopoulou, N., Smith, C., Cerrano, C., 2014. Spatial allocation of fishing activity on coralligenous habitats in Portofino MPA (Liguria, Italy). Coralligenous and other calcareous bio-concretions Congress, 29-30 October 2014, Slovenia: 118-123

Markantonatou V, Meidinger M, Sano M, Palma M, Ponti M, Cerrano C, 2013a. Stakeholder participation and the use of web technology for marine conservation. Advances in Oceanography and Limnology, 4:2, 260-276, DOI: 10.1080/19475721.2013.851117
Markantonatou, V., Sano, M., Cerrano, C., 2013b. Stakeholders, Technology and MPAs: Towards Integrated Management? Proceedings of the Global Congress on ICM (EMECS 10 -MEDCOAST 2013): Lessons Learned to Address New Challenges, 30 October - 03 November, Marmaris, Turkey: 293-304
Markantonatou, V., 2013c. Results of a survey for Mediterranean MPA managers, during the 2012 FORUM of Marine Protected Areas in the Mediterranean, 25-28 November, 2012, Antalya, Turkey.
Markantonatou, V., Marconi, M., Cerrano, C. Susceptibility assessment of seafloor to lost fishing gear in data poor areas. *In preparation*.
Meidinger M, Markantonatou V, Sano M, Palma M, Ponti M, 2013. Seafloor mapping and cartography for the management of Marine Protected Areas. Advances in Oceanography and Limnology. 4:2, 120-137, DOI: 10.1080/19475721.2013.848529
Ostrom, E., 1990. Governing the commons, Cambridge University Press, Cambridge.
Pomeroy, R., Douvere, F., 2008. The engagement of stakeholders in the marine spatial planning process. Marine Policy 32, 816–822.
Prell, C., Hubacek, K., Reed, M.S., 2009. Stakeholder analysis and social network analysis in natural resource management. Society and Natural Resources 22, 501–518.
Salmona, P., Verardi, D., 2001. The marine protected area of Portofino, Italy: a difficult balance. Ocean and Coastal Management 44, 39–60.
Sano, M., Markantonatou, V., Palma, M., Cerrano, C., 2012. Report on the results of the stakeholder engagement through the Online survey and the participatory workshop in Portofino MPA. MMMPA Project Deliverable D5.2.2.
Tempesta M., Otero M. 2013. Guide for quick evaluation of management in Mediterranean MPAs. WWF Italy, IUCN. 68 pp.

Chapter I

Monitoring MPA management effectiveness in Mediterranean Marine Protected Areas

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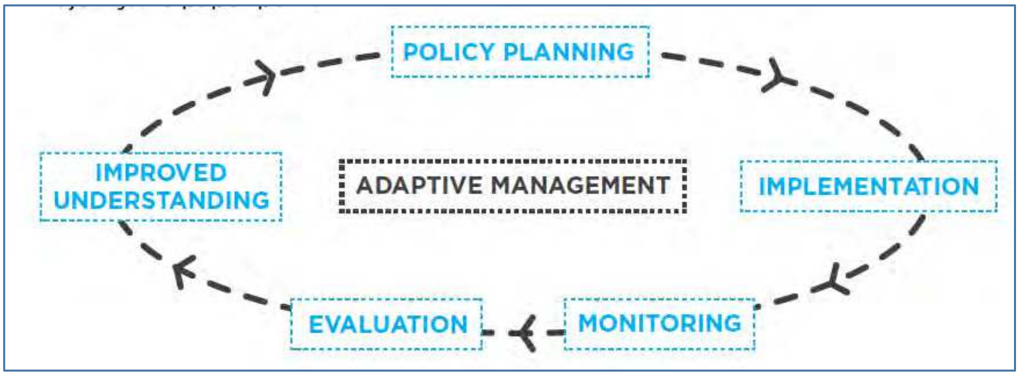
Abstract

Management effectiveness evaluation provides an organized and compacted way to integrate and synthesize information essential to MPA management, and enables managers to prioritize and address issues by setting new targets directly linked to management actions. We evaluated the management performance of five Mediterranean Marine Protected Areas: Portofino (IT), Tavolara-Punta Coda Cavallo (IT), Ustica (IT), Port Cros (FR), and Cabo de Palos (SP), following the existing guide of Tempesta and Otero (2013), which was updated during the process. Information was collected through a synthesis and integration of different approaches (semi-structured interviews with MPA Management Boards, staff and stakeholders, literature review, personal experience) during the period 2012-2015. Case studies were initially assessed separately using 21 performance indicators applied in the form of simple questions that described the general categories of (i) management and legislation; (ii) conservation features; (iii) pressures; (iv) communication and outreach. Finally the MPAs were compared in order to identify common challenges and good examples in MPA management. We highly recommend that the evaluation should be a cyclic process conducted by a neutral practitioner. Results should be disseminated in order to exchange knowledge, reach the adoption of common monitoring frameworks and increase MPA management effectiveness.

Keywords: Marine Protected Areas; MPA evaluation; marine resource management; performance indicators; assessment

1. Introduction[1]

Marine Protected Areas (MPAs) have been widely recognized as valid tools for the effective protection and maintenance of marine biodiversity, ecosystem health and the promotion of sustainable local socio-economic development (i.e. Mascia et al., 2010; McCook et al., 2010). Several EU Directives have highlighted the importance of well-managed MPAs and the national and regional networks of protected areas. For instance, the Convention of Biological Diversity (1992) required all Member States to develop guidelines for the selection, establishment and management of a system of protected areas (Katsanevakis et al., 2011). Moreover among the Aichi Targets, Target 11 of Biodiversity clearly states that by 2020 at least 10 per cent of coastal and marine areas should be effectively protected and equitably managed. This perspective does not only imply the establishment of new protected areas of high biodiversity, but also the diminishing of existing MPAs with limited or no management (commonly known as 'paper parks') that should move towards effective management and monitoring of their resources in order to achieve these targets. It is worth noticing that Abdulla et al. (2008) showed that the majority of Mediterranean MPAs are paper parks.



[1] This work has resulted in the following publications and deliverables:

Markantonatou, V., Sano, M., Cerrano, C., 2013. Stakeholders, Technology and MPAs: Towards Integrated Management? Proceedings of the Global Congress on ICM (EMECS 10 - MEDCOAST 2013): Lessons Learned to Address New Challenges, 30 October - 03 November 2013, Marmaris, Turkey: 293-304.

Meidinger M, Markantonatou V, Sano M, Palma M, Ponti M, 2013. Seafloor mapping and cartography for the management of Marine Protected Areas. Advances in Oceanography and Limnology. 4:2, 120-137, DOI: 10.1080/19475721.2013.848529

Markantonatou V, 2013. Results of a survey for Mediterranean MPA managers, during the 2012 FORUM of Marine Protected Areas in the Mediterranean, 25-28 November, 2012, Antalya, Turkey. Report, ITN MMMPA Project deliverable.

Markantonatou V, 2015. MPA management evaluation in Mediterannean Marine Protected Areas (MPAs). Report. Deliverable 5.2.3, ITN MMMPA Project.

Fig. 1. Adaptive management in Marine Protected Areas

An essential tool that may ensure pro-active, future-oriented management system delivering both socio-economic and environmental sustainability on a long-term MPA management is the effectiveness evaluation (Douvere, 2015). Management effectiveness evaluation is defined as the assessment of how well protected areas are being managed; primarily the extent to which management is protecting values and achieving goals and objectives (Hockings et al., 2006). The evaluation of management effectiveness is not simply a matter of measuring outcomes, but is a mean to improve understanding through a learning process on the present state and future decisions (Douvere, 2015). It provides an organized and compacted way to integrate and synthesize information essential to MPA management, and enables managers to prioritize and address issues by setting new targets directly linked to management actions (Leverington et al., 2010; Tempesta and Otero, 2013). The typical steps followed for a management evaluation is the selection of appropriate performance indicators, planning of the evaluation, collection and analysis of data, and communication of evaluation results to update decisions and adapt the MPA's management (Pomeroy et al., 2004).

The study aims to assist in identifying and addressing common barriers and challenges in Mediterranean MPAs in order to optimize management response using win-to-win examples implemented in MPAs. Using a strategic analytical approach that incorporates all management aspects we evaluate and compare different MPA management strategies in the Mediterranean. Moreover, this study provides updated information regarding where we are and what we have achieved in marine conservation adding value to previous work done in the past.

2. Methods

The analysis is split in two parts. First, preliminary semi-structured interviews were conducted with 12 Mediterranean MPA managers in November 2012, during the MedPAN Meeting "FORUM for Marine Protected Areas of the Mediterranean" (Antalya, Turkey). The interviews provided the basis for the general state of MPA management performance, and revealed the most important challenges and issues that currently Mediterranean MPAs need to encounter. In addition 5 well-established

Mediterranean MPAs (Portofino, Italy; Tavolara-Punta Coda Cavallo, Italy; Ustica, Italy; Cabo de Palos, Spain; Port-Cros, France) fed an in-depth evaluation of the management strategies adopted. These case studies are well established MPAs with years of experience in management. The work conducted is part of a larger European funded project – ITN Monitoring Mediterranean Marine Protected Areas (MMMPA). The research was conducted during the period 2012-2015.

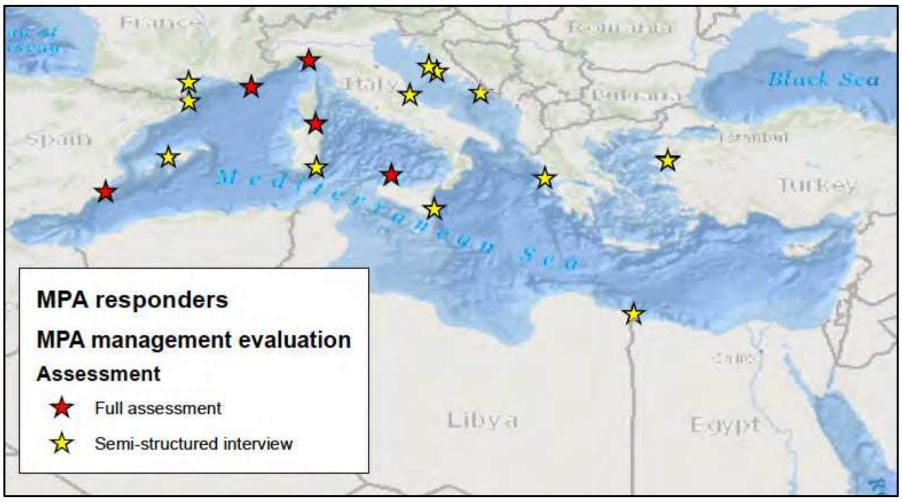


Fig. 2: Mediterranean MPAs that participated in the analysis. Colours indicate the process applied in every group.

The evaluation of MPA management performance for the 5 MMMPA-case studies was based on the IUCN-WWF-MedPAN guide (Tempesta and Otero, 2013). The guide was updated based on gained experience during the process. Three new indicators related to diving, boating (including mooring and anchoring) and marine litter were added and nine existing indicators were modified in order to better describe MPA management. This resulted in a total of 21 indicators that described all different MPA management aspects in the assessment.

Fig. 3: Step-by-step approach for management effectiveness to achieve adaptive and efficient MPA management

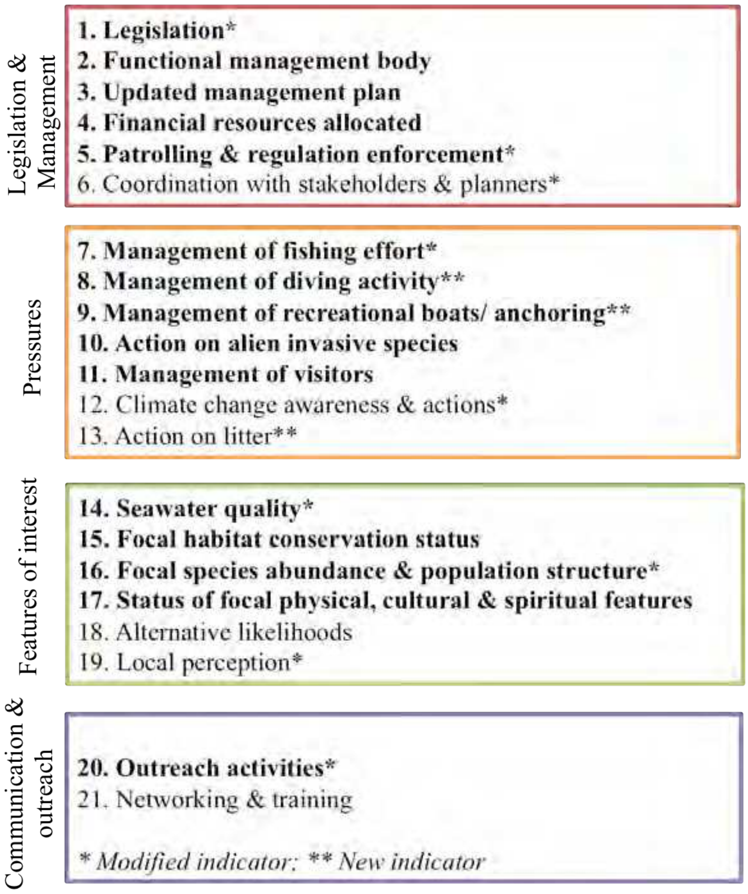


Fig. 4: Response indicators used in the evaluation of MPA management performance. Bold signifies indicators considered of primary importance in the assessment (Tempesta and Otero, 2013)

Information is organized in discrete management categories (legislation and management, features of interest, pressures and communication and outreach), formed in simple questions that assisted in scoring the performance indicators. Information was collected through a synthesis and integration of information through:

- Semi-structured interviews with MPAs' Management Boards, Scientific Committee, staff
- Semi-structured interviews and surveys with stakeholders
- Literature review
- Personal experience gained during the 'secondments' period of the MMMPA project

During the management evaluation, the difficulty and challenges in applying and measuring each indicator was also assessed in terms of time, skills and expertise, finances, and other resources necessary to measure the indicator. The MPAs were initially evaluated separately, taking into account the particular complexity at the level of cultural, social, political, and legislature aspects that characterize each MPA. The evaluation for each case study is presented in individual reports and indicator profiles of status and trends during the three years period that provide contextual information for every MPA. Furthermore, the five case studies that analytical information was collected through the evaluation were compared on the basis of monitoring frameworks and indicators, common challenges and successful stories.

3. Results and discussion

The most important management challenges and issues faced by the 17 Mediterranean MPAs are presented analytically in Fig. 5, using mainly examples from the 5 case studies that the guide was applied.

Although the five MPAs that their management performance was analytically examined are considered to be some of the best examples in the Mediterranean, still the main challenges (Table 1) identified and their impacts are very similar with the majority of the other MPAs examined through the semi-structured interviews. All five case studies represent a typical example of the Mediterranean MPAs and the status they currently face. Hence, successful examples from those MPAs can be adopted by other MPAs facing similar challenges and lead to win-to-win outcomes in new MPAs (Table 2). For instance, Portofino MPA represents a typically small MPA with many human activities overlapping and conflicting with each other. Tavolara- Punta Coda

Cavallo and Port Cros represent large areas that combine terrestrial and marine management, while Port Cros currently attempts the enlargement of the MPA adopting a strong bottom-up approach. Finally, Cabo de Palos MPA represents an area with priority on sustainable traditional fishing activities. The detailed assessment for each case study may be found in the Appendix. The results of the evaluation of management performance in examined MPAs in the Mediterranean are presented in Table 3.

Limited and constantly decreasing annual funding is the most common problem in the Mediterranean MPAs due to the recent financial crisis of the region. All managers agree that the annual funding has decreased about 10-30% compared to the previous years and does not cover the operational needs (covers from 1 to 2/3 of total expenses) in order for their MPAs to operate properly. From the 5 MPAs examined analytically, Tavolara- Punta Coda Cavallo has the most inadequate annual funding based on its needs, due to its large surface area and the multiple monitoring and conservation activities that take place in the area. Inadequate funding is considered a serious issue in many Mediterranean MPAs that has been repeatedly highlighted in several reports (Abdulla et al., 2008; Ojeda–Martínez et al., 2011; Agardi et al., 2011). Limited financing has multiple ‘domino effects’ on MPA management performance, particularly in terms of monitoring and action of ecological targets and human activities, surveillance and permanent experienced personnel. Jones (2011) highlighted the importance of ensuring that a sufficient degree of state funding to support the governance of the MPA, particularly in relation to enforcement and the local economy that can stimulate compliance of users (‘top-down approaches’). The state should respond to the MPA needs at a balanced way providing the means for better management rather than ‘capturing’ the MPA governance (Jones, 2011). Although no ideal-funding MPA was identified in the present analysis, we were able to locate some successful funding systems in the examined MPAs. For instance, the distribution of annual funds from the italian Ministry is based on indicators. Yet, it covers a small part of the operational cost from the multiple activities conducted in Tavolara- Punta Coda Cavallo and Portofino MPAs. Additional funds arrive from the local authorities (members of the management board) and projects, some of which cover the staff salaries. An important achievement of the italian MPAs is an additional 4-year funding specifically for covering the monitoring needs of the MPAs. Managers however suggested that indicators should be re-evaluated and funding should be distributed not only based on the objective management needs but also based on the management performance. In the Port Cros National Park funding is distributed from the Ministry in four parts in order to directly support financially the scheduled activities, while private companies that promote sustainability and green energy provide additional funding.

Surveillance is closely linked with the adoption of bottom-up approaches, where the state controls through the laws and regulations to ensure that biodiversity and marine resources are receiving the required protection (Jones, 2011). Almost all MPAs face the issue of limited surveillance, particularly during the night. Incidents of sport fishermen diving with underwater tanks, lights and targeting species of focal importance (e.g. groupers) are being frequently reported. Violations of the MPA regulations by visitors and users such as the speed limits for leisure boats, the unauthorized anchoring, mooring and fishing, and entering in the no take zone were also reported. The number of violations usually depends from the surface area of the MPA, with larger areas being more difficult to survey.

When the financial status of the MPA allows (e.g. expenses for fuel, MPA boat), the MPA management board may additionally patrol the area. However managers claimed that this has limited effectiveness since they do not have the legal means to enforce the laws themselves and establish penalties to violators. The fact that only the coastguard may seize penalties in combination to the wide area under its responsibility result most of the times in the inadequate patrolling of the area. In Cabo de Palos-Islas Hormigas MPA surveillance is carried out by a semi-private company ("TRAGSA") that is responsible for patroling all the Marine Reserves of Fishing Interest in the Region. The rangers do have the authority to penalize violators but their enormous spatial range of responsibility makes it difficult to be efficient. Small communities often hold personal relations with the legal authorities and/or violators, resulting in inadequate enforcement, while in several cases although the violator is prosecuted the legal system is inactive to verbalize penalty. From the MPAs examined, the only exception is the Port Cros National Park where rangers themselves are specially trained and have the authority by the Ministry to enforce the law, and the management board can establish its own regulations in the MPA area.

The enforcement of laws largely varies depending on the willingness of authorities to prosecute and impose fines. Zakynthos MPA has minimized this issue by setting boat observers while the authorities survey the area. However, managers claimed that penalties have a minimal input to the budget but are of major importance for the MPA' s status and compliance of users. Our results are in accordance with Tempesta and Otero (2013) that indicated patrolling and law enforcement are closely linked to management objectives and activities. This can be verified easily using the example of Cabo de Palos- Islas Hormigas MPA that, due to reduction of funds, the maintenance activities and surveillance were limited for a 3 years period of time and impacts were evident on the fish stocks in terms of abundance and mainly biomass (Garcia-Charton, pers. communication).

Fig. 5: Common challenges in Mediterranean MPAs

Top-down approaches should be adopted in order for the MPA managers to have the legal tools to support conservation. However, bottom-up approaches should also be established in MPA management by involving and empowering local actors in deliberations and decisions, in order to achieve decentralized decision-making processes (Jones, 2011). Stakeholder engagement is also essential for the generation of new information, the coordination and enforcement of common rules and the mitigation of conflicts on the use of marine resources (Folke et al., 2005). Although a great progress has been noticed in adopting bottom up approaches, the Mediterranean MPAs are still far from the desired collaborative MPA management (Markantonatou et al., 2013). Managers reported difficulties in the participation of all relevant stakeholders in decision-making due to the great expectations that local users have from the management board, and the limited understanding of the linkages of conservation values and the economic sustainability of an area.

Common conflicts between managers and actors appear to be mainly with recreational and small-scale fishermen. The most integrated user group in the MPA management is divers that often collaborate with the management board, they notify for possible damages and volunteer in monitoring and litter collection from the sea bottom. Portofino MPA for instance reported inadequacy to engage with all stakeholders due to important interests and conflicts particularly with fishermen. However in this case, since the Portofino MPA establishment a lot of progress has been made to mitigate conflicts and find a balance between users and resources. Best examples from the five case studies were Tavolara-Punta Coda Cavallo, Ustica and Port Cros MPAs that a worth noting effort is being made to actively involve stakeholders into decisions and MPA management through frequent meetings, public events and visits on the field. In Ustica MPA the new Director gave priority to stakeholder participation and interaction, highlighting the importance of stakeholder participation to support good management.

An approach that has been recently recognized for the benefits regarding stakeholder engagement is social network analysis (SNA), where the social environment and the relationships between actors are examined (e.g. Prell et al., 2008; 2009). Very few MPAs in the Mediterranean however have applied a social perspective analysis, apart from compiling a stakeholder list. From the case studies examined, only two (Portofino MPA by Markantonatou et al., 2016; and Cabo de Palos MPA by Hoggs et al., in prep.) have applied a proper SNA where useful outcomes have been produced regarding the power and the influence of stakeholders in decisions and their access to resources. As Scianna et al. (2015) suggested a comprehensive organizational science analysis could benefit in the interpretation and formal MPA management assessment taking into account the nature and impact of ties developed between actors and the MPA.

Table 1. Most common challenges and issues currently faced in the Mediterranean MPAs and their impacts

Challenge	Impacts
Funding decreasing	-Inadequate monitoring and maintenance capacity -Limited capacity to implement innovative approaches and tool -Inadequate surveillance due to lack of fuels, boat or cameras -Restricted organization of engagement events and information of public, outreach activities -Incomplete infrastructure
Limited surveillance and law enforcement	-Illegal activities particularly at night -Impact on conservation objectives and long-term sustainability (e.g. decrease of catch, habitat degradation etc.) -Loss if income from penalties -Exemplified illegal activities, loss of trust
Stakeholder engagement	- Sharpening of conflicts - Marginalized groups -Inadequate information and knowledge

	-Lack of trust, transparency, mutual understanding -Incompliance with laws -Delay and inappropriate solutions
Inconsistent legislation that lacks management experience	-Long bureaucracy -Restrictions in salaries of permanent experienced personnel and incompatible responsibilities (e.g. administration cannot perform monitoring and vice versa) -Political pressures -Policy gaps and inconsistencies with other levels of authorities (e.g. Ministry vs. Region), slight management implementation and bottom-up approaches aspects -Unrealistic laws (e.g. violator should be caught in the act while fishing and catching the fish) and inability of rangers to enforce law -Lack of compulsory MPA monitoring (with impact on funding)
Inadequate monitoring of habitats and species	-Knowledge gaps -Heterogeneous monitoring frameworks and indicators applied -Inadequacy to achieve conservation targets
Inadequate monitoring of human activities	-Potential of biased results since users themselves provide the data -Limited understanding of potential impacts and critical thresholds (carrying capacity) -Habitat degradation, depletion of stocks -Decrease of long term sustainable economic development
Lack of management plan or updated management plan	-Lack of essential tools to manage the area -Lack of specific and clear measurable management objectives

A clear regulatory framework is essential for the effective achievement of the goals and targets of any protected area. The national and international contextual attributes, particularly those related to strategic statutory biodiversity conservation obligations, need to be considered as the legal tool in the hands of managers (Jones, 2011). If this framework does not exist, many management measures cannot be undertaken and/or enforced (Tempesta and Otero, 2013). The MPA managers reported great legislation inadequacy particularly linked to long bureaucratic processes in the Mediterranean. Although this issue varies greatly by country, most managers perceive the legal system unrealistic, lacking of management experience, practical elements and ignoring bottom up approaches. In some cases inadequate cross-jurisdictional coordination between different administrations takes place (e.g. Markantonatou et al., 2016).

In the Mediterranean usually high objectives arrive from the international level laws (e.g. the Barcelona and Bern Conventions, the Habitats Directive, the Water Framework, the Marine Strategy Framework Directive etc.). Nationally, the most important law is the Decree of establishment, but also laws regarding the water status and biodiversity. Nevertheless, MPAs may be under a particular status, like Cabo de Palos- Islas Hormigas that is nationally recognised as a “Fisheries Reserve”, and therefore their objectives and actions are mainly focused on fisheries. This may have an impact on mitigating other human activities that are not linked directly with fisheries. In the case of Cabo de Palos- Islas Hormigas MPA however, the relative laws have been recently updated under a participatory approach, in order to mitigate diving activity and protect effectively vulnerable habitats of the area (Garcia-Charton and Hogg, pers. communication).

At the local scale the most important tool is the management plan for a successful MPA management (Maxwell & Morgan, 2012). Adaptive management plans are highly recommended in order for the MPA to have future orientated vision and goals along with a strategy to attain these goals in well-defined time limits (Tempesta & Otero, 2013; Scianna et al., 2015). Therefore the 'management plan' is part of the strategy of the organizations and it describes how the organization is going to reach its goals. It is important these goals to be realistic though. Unrealistic expectations of what MPAs can deliver and goals may lead to uninformed design and reckless proliferation of such efforts (Pomeroy et al., 2004). It was noted that MPAs that were also SPAMIs had a better performance regarding the legal tools available, the presence of a management plan and advanced monitoring, as the relative Protocol requires.

In the Mediterranean MPAs, the management plan may define the relative authorities and their roles, the MPA boundaries, its main objectives and some regulations. From the semi-structured interviews it was evident that some MPAs located in the south Mediterranean have still not established a management plan (Abdullah et al., 2008). Nevertheless, since the time of the interviews, significant progress has been made by WWF and MedPAN to promote operational MPAs in this area through consultancy, projects and funding. Regarding the MPAs having a management plan, there seems to be a lack of specific measurable targets within the management plan in some cases that may assist in the identification, prioritization and management of specific elements. In other cases it is more convenient the establishment of an action plan that is more frequently updated. The 2006 reform of the Charter in the French national parks including Port Cros MPA that suggests the extension of the park, stimulated a series of stakeholder engagement meetings in order to set visions, goals and targets in a fully collaborative process with the local community. This process has improved the public acceptance of the park and participation incentives (Hogg et al., in prep.).

Table 2. Common challenges in Mediterranean MPAs and suggestions adopted from good management practices

Challenges	Good examples
Limited funding	- Collaborations with Universities (students) - Promotion of local products - Offers and dissemination (e.g. social media, press) - Establish a minimum fee for any type of activity taking place in the area - Attract private sector (e.g. insurance companies) - Establish certification of activities and products - Part of funding arrives at the beginning of monitoring activities - Establish a fee for visitors - Conduct cost-benefit analysis, financial sustainability strategy - Establish committee for transparency & good financial management
Limited surveillance & law enforcement	- Information of stakeholders and tourists to ensure that everyone is aware of regulations - Meetings with local in order to build trust bond relationships and report illegal activities - Patrolling with MPA staff present to ensure enforcement - National or regional agreements with coastguard - Partial funding from regional authorities - Permanent cameras system - Invest on local trust, collaboration, responsibility - Local responsibility and reporting
Stakeholder engagement	- Constant and face-to-face interaction with stakeholders - Frequent meetings, collaboration, dialogue, negotiation - Compile stakeholder list, conduct stakeholder analysis and social network analysis - Empowerment and co-production of knowledge - Provide feedback - Organize consultations between groups, stimulate users to suggest solution, work towards reaching a common solution - Important to be aware of value for residents/ profitability for business
Legislation	- SPAMI is the only law that obliges MPAs to have a management Consortium, a management plan and monitor species and habitats of particular importance
Monitoring of habitats & species	- Collaborations with volunteer divers (citizen science), apps - Apply new technologies - Collect geo-referenced information - Establish a list of focal species present in the area - Awareness, education, dissemination, outreach (social media, press, events, info points, brochures etc.) - Harmonize indicators and monitoring plans with other MPAs - Specialized training of MPA staff and exchange of experiences with other MPAs
Monitoring of diving and response	- Studies on carrying capacity per diving site in terms of number of dives per day, and not only per year - Inform/train diving operators regarding diving behaviour underwater, guide, management of diving impact, safety equipment and nautical navigation

	- Establishment of diving quality certification to operators (emissions, equipment etc.) - Underwater signs and surveillance - Electronic monitoring through web portal and apps showing sites availability - Monitor number of dives, diving level of divers, per diving site through logbooks and personal observation during surveillance - Establish mooring sites (Jumper diving buoys) - Underwater surveillance for diving behaviour - Spatial and temporal closures of diving sites in order to mitigate impacts (particularly after warm summer period due to massive mortality events) - Environmental-Social-Economic studies regarding characteristics of divers, preferences, value of diving sites etc. - Establish agreements about responsibilities and commitments - Awareness of value for tourism
Monitoring fishing and response	- Electronic log books and apps - Effort on geo-referenced information - Combine monitoring strategies to validate data (e.g. logbooks, on-board observers, interviews, questionnaires etc.) - Discriminate and regulate strictly destructive fishing practices - Establish agreements about responsibilities and commitments - Apps that provide feedback from catch
Recreational boating & anchoring	- Development of apps & habitat map - Inform boaters in ports for zoning and regulations, surveillance system - Studies on environmental impacts; behaviour and preference points (interviews/ surveys to users) - Application with habitats present, prohibitions and carrying capacity - Monitor through surveillance cameras and air photos (ultra light plane) - Awareness of value for tourism
Management Board with no knowledge on marine conservation	- Integrate scientists and NGOs into Management Body - Scientists need to communicate their results in common language

Another issue that some managers reported is the administrative character of the MPA Consortiums having limited knowledge on management and conservation issues. In other cases decisions are entirely science-based with no bottom-up approaches and consultations with other entities integrated (e.g. NGOs, users etc.). In most MPAs a scientific Committee is established having an advisory role in management, or in another cases scientists could be part of the management body, such as in the case of Portofino MPA and the University of Genova. In Port Cros, the management board includes representatives of the central government, the regional government, and members chosen for their national or local relevance (for example, landowners, residents, users, and representatives of environmental NGOs or sectoral trade organizations), while scientific councils further advise the management board. A first attempt in 2013 has been made by the WWF and the Mediterranean Network of MPA managers (MedPAN) in order to bridge gaps between scientists and managers. In this meeting managers suggested the creation of a web platform at a regional and national level to assist communication (Di Carlo, 2014).

Stakeholder participation and the centralization of decisions appears to be closely linked to this issue. Based on the managers' perspective the most important actors that should be engaged in MPA management are administration and scientists, while the least important ones are recreational fishermen and private sector (Markantonatou et al., 2013). This highlights the concept of the Mediterranean where concentration of power and information on decisions are mainly to those categories, rather than the involvement of all actors (Markantonatou et al., 2016; Hoggs et al., in prep.). It is necessary all MPAs to focus their effort towards the design and establishment of participatory approaches which will guarantee the MPA vision and conservation goals are in line with existing local plans (Douvere, 2015; Tempesta and Otero, 2013). Introduction of additional programs that will improve community stewardship and foster a shared understanding, such as 'education' or 'training' sessions for local administrations, tourist agencies and community members are also suggested in parallel (Hogg et al., in prep.). In the case of Port Cros for instance, the fact that when the MPA was initially established the strict regulations that were set and lack of knowledge at that time about the benefits of stakeholder engagement resulted to the slow abandonment of the island from its residents (Mr. S. Monroe, Director of Porquerolles National Park, pers. communication). Hence during the new Charter managers has made a great effort in order to include the opinion and suggestions of local community in the most interactive way that took more than 3 years to complete.

Networking between the MPA and other relevant forums and organizations at national and international level is an important aspect in management (Scianna et al., 2015). Italy and France have established national MPA networks where there is constant interaction and exchange of experiences between them. In Port Cros and Tavolara MPAs training of MPA staff may take place in order to promote the most updated and effective approaches in the Mediterranean basin. Port Cros publishes its own scientific journal addressed to the scientific community, while the majority of MPAs have multiple dissemination and awareness activities addressed to users and the general public (brochures, signs, website, events, support of cultures and art etc.). Although some MPAs (e.g. Portofino MPA) have not established a particular education plan, their activity in most cases includes several educational events and dissemination material.

Regional or national responsible authorities generally monitor seawater quality in the MPAs. Tempesta and Otero (2013) reported that there is a difficulty for MPAs to retrieve this information, however managers supported the opposite during the interviews of the present study. The MPA staff collaborating scientific institutes may also collect their own information. The MPA management board may as well collaborate with research or academic institutes for the monitoring of focal species and habitats. The need for the establishment of standardised monitoring plans and indicators in the Mediterranean region in order to secure efficient and comparable results, is urgent (Tempesta and Otero, 2013; Jones et al., 2011). Successful examples of innovative monitoring and mapping methods (e.g. acoustic information) have been established in the most advanced MPAs. The biological evidence in all the case studies examined indicates conservation has benefited the good status of species and habitats with great abundance and biomass reported on benthic communities and fish populations (see Appendix for details and references), in accordance with the previous assessment of Tempesta and Otero (2013). However, some areas may suffer from seasonal massive mortality events and there is still limited information and knowledge regarding the response of vulnerable habitats such as coralligenous, to human and natural pressures (Ballesteros et al., 2006). Inadequate and/or inexistent monitoring of focal species, habitats, and human activities in Mediterranean MPAs is mainly due to financial difficulties, the inability of the MPAs to have permanent and experienced personnel, the lack of collaboration with users and local community, inadequate scientific knowledge on some ecological aspects, lack of studies on carrying capacity.

The majority of MPAs are struggling to keep a balance between tourism activities and conservation that are the main reason for exceeding the capacity of vulnerable areas. Tourism and relative activities were considered to be the main threats in most MPAs, with special emphasis the anchoring on *Posidonia oceanica* meadows. Tavolara-Punta Coda Cavallo and Port Cros MPAs have made significant effort to define capacity thresholds for recreational activities (diving, boating, tourists and beach users) in order to secure conservation targets. Licenses and authorization for human activities is the primary tool that the MPAs have for monitoring.

Advanced MPAs however have developed innovative approaches to increase the efficiency of their monitoring data and management capacity. Tavolara for instance has established an app that depicts sea bottom habitats and informs recreational boats where to anchor. Through this tool the MPA achieves not only pro-action but also accurate monitoring of the relevant activity. Diving logbooks are verified with information collected by the MPA during surveillance. Portofino MPA and Port Cros verify the information from fishing diaries through interviews and surveys in order to attain unbiased data. Information coming from monitoring informs decisions and measures are being taken in order to mitigate threats on vulnerable habitats and species. In Port Cros MPA underwater signs attached to the diving buoys and patrolling from rangers is made in order to ensure good diving behaviour. Some MPAs (e.g. Tavolara-Punta Coda Cavallo and Port Cros) have adopted the 'jumper buoys', which are considered less impacting for the sea floor.

The results of the analysis were limited regarding some indicators underling gaps in MPA management. Climate change and invasive species for instance are not easily managed issues (e.g. massive mortality events), hence there are a few examples in advanced MPAs of management response, but these topics are considered emerging threats in all the Mediterranean. *C. taxifolia* for instance is directly eradicated using volunteer divers (Cottalorda et al., 2011), but *C. racemosa* has been reported in all case studies with tremendously increasing outspreading trends (Ruitton et al., 2009). From the MPAs examined, only 3 (Tavolara, Portofino and Port Cros) monitor erosion, mainly through photographic techniques.

The present study intended to deep inside the MPA management aspects that may assure a balance between conservation and socio-economic status of the areas. Effective MPA management is a multi-dimensional issue involving a wide range of different parameters that compile the management strategy and the factors that it is influenced by existing social conditions, financial support, cultural practices (e.g. values, attitudes, and beliefs), surveillance and political will, legislation power (Douvere, 2015). It is a combination of approaches that must combine the role of the state, the local community and the markets through a balance of approaches considering the existing conflicts that can secure equal distribution of resources and good governing (Jones, 2011).

Table 3: Results of the evaluation of management performance in examined MPAs in the Mediterranean. The date of the MPA establishment as indicated by relevant Decrees is reported under each MPA. Bold specify indicators of primary importance in MPA management. Symbols indicate: (*) Declared SPAMI; (**) Declared FRA; (#) Porquerolles integrated in the heart of the Port Cros Marine Reserve in 2012; (˚) Original indicator from Tempesta & Otero (2013) has been modified; (˚˚) New indicator added to the evaluation

2014- 2015 ASSESSMENT						
	Name of the indicator	Portofino (1999)*	Tavolara (1997)*	Ustica (1986)	Cabo de Palos (1995)**	Port Cros (1963)*#
Legislation & Management	Existence of legislation on MPAs˚	blue	blue	blue	orange	blue
	Existence of a functional management body	blue	blue	blue	yellow	blue
	Existence of a updated management plan	blue	green	yellow	yellow	blue
	Financial resources allocated to the MPA	yellow	orange	yellow	yellow	yellow
	Patrol and regulation enforcement˚	green	green	green	green	blue
	Coordination with stakeholders and planners˚	yellow	blue	blue	blue	blue
Features of interest	Seawater quality	blue	blue	orange	orange	blue
	Focal habitats˚ conservation condition	blue	blue	blue	blue	blue
	Focal species abundance and population structure˚	green	blue	green	green	blue
	Status of focal physical, cultural and spiritual features	blue	blue	green	green	blue
	Alternative Livelihoods and/or Income Generating Activities (AL/IGA)	orange	blue	blue	orange	green
	Local perception of the MPA˚	green	blue	yellow	yellow	blue
Pressures	Management of fishing effort˚	green	blue	orange	green	blue
	Monitoring of diving activity˚˚	green	blue	green	green	green
	Monitoring of anchoring and recreational boating˚˚	green	blue	green	yellow	green
	Action on alien invasive species	green	blue	green	green	blue
	Management of visitors presence	green	green	blue	orange	yellow
	Climate change awareness and actions˚	green	blue	orange	yellow	blue
	Action on litter˚˚	green	green	yellow	orange	green
Communication & outreach	Existence of outreach activities˚	green	blue	green	orange	blue
	Networking and training	blue	blue	yellow	yellow	blue

An important aspect for improving the management effectiveness in the existing system of MPAs is the consolidation of the knowledge base, regular evaluation of management plans and integration processes and mechanisms, that will strengthen trust between all stakeholders, whilst mobilizing them to achieve more ambitious objectives on different geographical levels (Walton et al., 2013).

5. Conclusions

With the growing recognition for the need to move beyond ideological arguments as to which management approach is best, and rather develop governance approaches that combine the steering roles of the state, the market and the people, attention must be given to identifying good practice and its transferability to other MPAs (Jones, 2014). MPA performance needs to be improved in order to halt environmental and socioeconomic decline (Mora and Sale, 2011). We have tried to highlight the most important and mention win-to-win examples, or describe the true nature of issues under these problems using the detailed information provided by the management assessment of the five case studies.

The assessment provides a multi-disciplinary insight and clarity regarding the extent to which management is protecting values and is achieving goals and objectives in a wide range of scales and aspects (Tempesta and Otero, 2013). We need to clarify that this is a quick evaluation guide that explores the most important MPA management aspects, issues and challenges, however it does not exhaust them, since the aim of the study was to identify main MPA challenges and guide the future orientation of the present Thesis. Although there is no 'one-model-fits' to all cases, the steps and the key issues examined are always the same (Dourvere, 2015). Thus, the suggestions made here are applicable to any MPA worldwide. It must be noted that the analysis is based primarily on the expert views of the respondents to this study, rather than an extensive literature review and analysis, and hence may not represent the views of other experts or of people who are affected by a given MPA.

The evaluation is a periodically cyclic process and should be disseminated in order to exchange knowledge, reach the adoption of common monitoring frameworks and increase MPA management effectiveness (Tempesta and Oterp, 2013). The process demands a clear understanding of management aspects and trade-offs between conservation features, threats and actions (Pomeroy et al., 2004). The assessment should be conducted ideally through an engagement process of the MPA management boards, scientists and local stakeholders in the form of workshops and round tables, in order to achieve objective and realistic results and inform efficiently decisions (Pomeroy and Douvere, 2008). If the engagement capacity is not dynamic, stakeholders can be involved in the following steps of decision making, at once all together or in groups depending on the relevant topics. External evaluators may also conduct the analysis, under the condition that the practitioner gains experience and active involvement in the MPA management, stakeholders and local community in order to gain deep understanding of the area's issues. It was noticed that in some cases the neutral evaluator improved significantly the assessment by extracting information from users that could be difficult to be stated during an engagement process due to power inequalities or marginalization.

The effectiveness of MPA management highly depends from the local characteristics and peculiarities of each area, the challenge and local context that is has emerged (Jones, 2011). For instance a continuing opposition towards the MPA that has been initiated from the past could still cause an imponderable factor for management success as in the case of Portofino MPA (Markantonatou et al., 2016). For these reasons comparisons of scores between MPAs should be applied with caution. In any case, the present study attempted to take into consideration the marked differences between countries in distinct economic, social and cultural features that characterize the Mediterranean region, using indicators that are flexible enough to be adapted to local site conditions (Pomeroy et al., 2004). A possible solution regarding management effectiveness guidelines is to consider the weighting of those indicators based in each MPA priorities and targets as set by their management and action plans. We are in accordance with the recent study by Scianna et al. (2015) that indicated inadequacy of existing management assessment guides to clearly identify the general 'vision', or the 'strategy' in terms of organizational science.

The present assessment of MPA management effectiveness provided an important input from a methodological point of view, by suggesting an updated guideline and new performance indicators corresponding to a wide variety of management aspects. The approach is straightforward and consists a relatively cheap tool that enables managers to learn from successes and failures in a formal way. The guidelines allow the comparison between MPAs in order to assess the general status of MPAs performance in Mediterranean, and promote the sharing of knowledge and good practices that may improve MPA management. Managers might not only use evaluation results to improve future performance and document achievements, but also to report and seek assistance in addressing barriers to stated management goals and objectives or formulating new ones.

Acknowledgements

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References

Abdulla A., Gomei M., Maison E. and C. Piante, 2008. Status of Marine Protected Areas in the Mediterranean Sea. Malaga: IUCN and France: WWF. 152 p.

Agardy, T., di Sciara, G.N., Christie, P., 2011. Mind the gap: addressing the short-comings of marine protected areas through large scale marine spatial planning. Mar. Pol. 35, 226-232.

Ballesteros, E., 2006. Mediterranean Coralligenous Assemblages, Oceanography and Marine Biology - An Annual Review, A Synthesis of Present Knowledge. CRC Press. doi:10.1201/9781420006391.ch4

Cottalorda, J.M., Barcelo, A., Barral, M., Bergere, H., Fromentin, J.Y., Pironneau, E., Houard, T., 2011. Résultats de la campagne d’octobre 2010 de recherche et d’éradication de la Chlorobionte envahissante Caulerpa taxifolia (Vahl) C. Agardh. Scientific Reports of Port Cros National Park 25, 199–202.

Di Carlo, G., 2014. Bridging Mediterranean scientists and resource managers. Regional experience-sharing workshop of the MedPAN network, "Monitoring for managing Mediterranean Marine Protected Areas" November 2014, Tirana, Albania.

Douvere, F., 2015. World Heritage Marine Sites Managing effectively the world’s most iconic Marine Protected Areas. United Nations Educational, Scientific and Cultural Organization, UNESCO, United Nations Educational, Scientific and Cultural Organization. pp.118.

Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive governance of social-ecological systems. Annual Review of Environment and Resources 30, 441–473. doi:10.1146/annurev.energy.30.050504.144511

Hogg, K., Semitiel- García, M., Noguera-Méndez, P. Cabo de Palos-Islas Hormigas and Cabo de Gata-Níjar Marine Reserves, Spain: A governance analysis. In Prep.

Hogg, K., Noguera-Méndez, P., García, M.S. Governing Marine Protected Areas: Lessons from three north-western Mediterranean MPAs. In Prep.

Jones, P.J.S., 2011. The Wash & North Norfolk Coast European Marine Site–governance analysis. in PJS Jones, W Qiu and EM De Santo (Eds) Governing Marine Protected Areas: getting the balance right - Volume 2. Technical Report to Marine & Coastal Ecosystems Branch, UNEP, Nairobi, 40-59pp.

Jones, P.J.S., 2014. Governing Marine Protected Areas : Resilience Through Diversity, 1st ed. Routledge, Oxon.
Mascia M.B., Claus C. A., and R. Naidoo(2010). Impacts of Marine Protected Areas on fishing communities. Conservation Biology 24:1424–1429.
Katsanevakis, S., Stelzenmüller, V., South, A., Sørensen, T.K., Jones, P.J.S., Kerr, S., Badalamenti, F., Anagnostou, C., Breen, P., Chust, G., D'Anna, G., Duijn, M., Filatova, T., Fiorentino, F., Hulsman, H., Johnson, K., et al., 2011. Ecosystem-based marine spatial management: Review of concepts, policies, tools, and critical issues. Ocean & Coastal Management 54, 807-820.
Leverington, F., Lemos Costa K., Courrau, J., Pavese, H., Nolte, C., et al. 2010. Management effectiveness evaluation in protected areas – a global study. Second edition 2010. The University of Queensland, Brisbane, Australia, 101pp.
Markantonatou, V., Sano, M., Cerrano, C., 2013. Stakeholders, Technology and MPAs: Towards Integrated Management? Proceedings of the Global Congress on ICM (EMECS 10 -MEDCOAST 2013): Lessons Learned to Address New Challenges, 30 October - 03 November 2013, Marmaris, Turkey: 293-304.
Markantonatou V, Noguera P, Semitiel-Garcia M, Hogg, K, Sano M, 2016. Social networks and information flow: building the ground for collaborative marine conservation planning in Portofino Marine Protected Area (MPA). Journal of Ocean and Coastal Management, 120: 29-38
Markantonatou V., Mangi, M., Cerrano, C. MPA awareness in italian Marine Protected Areas. In prep.
Maxwell S.M. and Morgan L.E., 2012. Examination of Pelagic Marine Protected Area Management, with recommendations for the Pacific Remote Islands Marine National Monument. Marine Conservation Institute, Seattle. 99 p.
McCook L., Ayling T., Cappo M., Choat J. H., Evans R. D., De Freitas D. M., Heupel M., Hughes T. P., Jones G. P. , Mapstone B., Marsh H., Mills M., Molloy F. J., Pitcher C. R., Pressey R.L., Russ G. R., Sutton S., Sweatman H., Tobin R., Wachenfeld D.R., and D. H. Williamson (2010). Adaptive management of the Great Barrier Reef: a globally significant demonstration of the benefits of networks of marine reserves. Proceedings of the National Academy of Sciences of the United States of America 107:18278–18285.
Mora, C., Sale, P.F., 2011. Ongoing global biodiversity loss and the need to move beyond protected areas: a review of the technical and practical shortcomings of protected areas on land …. Mar. Ecol. Prog. Ser. 434, 251–266. doi:10.3354/meps09214
Ojeda–Martínez C., Bayle-Sempere J. T., Sánchez–Jerez P., Salas F., Stobart B., Goñi R., Falcón J.M., Graziano M., Guala I., Higgins R., Vandeperre F., Le Direach L., Martín–Sosa P. and S. Vase (2011). Review of the effects of protection in marine protected areas: current knowledge and gaps. Animal Biodiversity and Conservation 34(1):191-203
Pomeroy R, Parks J, Watson L. 2004. How is your MPA doing? A guide book of natural and social indicators for evaluating marine protected area management effectiveness. IUCN, Gland, Switzerland and Cambridge, UK.
Prell, C., Hubacek, K., Quinn, C.H., Reed, M.S., 2008. "Who"s in the network?' When stakeholders influence data analysis. Systemic Practice and Action Research 21, 443–458. doi:10.1007/s11213-008-9105-9
Prell, C., Hubacek, K., Reed, M.S., 2009. Stakeholder analysis and social network analysis in natural resource management. Society & Natural Resources 22, 501–518. doi:10.1080/08941920802199202
Ruitton, S., Thibaut, T., Cottalorda, J.M., Verlaque M., Bonhomme, P., Lassauque, J., Fourt, M., 2009. Evaluation de l'impact de Caulerpa racemosa sur les communautés benthiques coralligènes du Parc national de Port-Cros: les peuplements patrimoniaux de Cystoseira spp. et de Corallinaceae. GIS Posidonie publ., Marseille: 1-57.

Scianna, C., Niccolini, F., Gaines, S.D., Guidetti, P., 2015. “Organization Science”: A new prospective to assess marine protected areas effectiveness. Ocean & Coastal Management 116, 443–448. doi:10.1016/j.ocecoaman.2015.09.005

Tempesta, M., Otero, M., 2013. Guide for quick evaluation of management in Mediterranean MPAs. WWF Italy, IUCN, 68 p.

Chapter II

Social networks and information flow: building the ground for collaborative marine conservation planning in Portofino Marine Protected Area (MPA)

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Abstract

Early involvement and active participation of stakeholders is a prerequisite strategy for the effective implementation of marine conservation and management measures in any Ecosystem-Based Management approach. Stakeholder engagement accrues numerous benefits to natural resource management. This study aims to explore social networks that may foster communication and stakeholder engagement processes for sound decision-making and adaptive co-management of resources. Stakeholder Analysis and Social Network Analysis was applied to examine structural patterns in social networks and to identify central actors with the capacity to serve as communication hubs, boosting information flow and enhancing stakeholder participation in management decisions. Portofino Marine Protected Area (Ligurian Sea, Italy) is used as a case study for supporting the upcoming engagement strategy towards the expansion of the area targeting more effective conservation. The obtained results show that even though there is a significant progress towards stakeholder participation, more effort should be made on strengthening the weak relationships between actors in order to integrate marginalized actors into the process and assist information to flow more readily through several communication channels in the network. Finally, we argue that interventions geared towards coupled face-to-face and online participation strategies may facilitate engagement and the co-production of knowledge through frequent interactions.

Keywords: Marine Protected Area; Social Network Analysis; Stakeholder engagement; Information flow; Adaptive resource management

1. Introduction[1]

There is an increasing understanding that the complexity of most ecosystems is matched by equally complex social settings; hence governance aspects, social and ecological systems should be considered together (Ostrom, 1990). Stakeholder engagement is a continuous learning process that increases social capital, deepens mutual understanding and promotes the exploration of possible solutions, facilitating cooperation in decision-making (Hogg et al., 2013; Pomeroy and Douvere, 2008). Particularly in Marine Protected Areas (MPAs) participation is essential for the generation of information, the compliance with common rules and the mitigation of conflicts on the use of marine resources (Folke et al., 2005). Although widely acknowledged by several EU Directives, stakeholder participation is a complicated process that involves expensive and time-consuming procedures, which often results in a limited audience and engagement potential (Pomeroy and Douvere, 2008). Furthermore, the heterogeneity of groups and the emergence of personal interests may pose conflicts or power inequalities capable of influencing perceptions and decreasing the efficiency of policy interventions (Prell et al., 2009). To achieve successful stakeholder participation and adaptive co-management of resources two fundamental components should be considered: the participation of representatives of all actors' perspectives and interests influencing or being influenced by decisions, and the provision of adequate information and tools that will support communication and mutual understanding among stakeholders (Bodin et al., 2006; Markantonatou et al., 2013a).

Information and Communication Technologies (ICTs), ranging from simple dissemination tools such as Social Media and multimedia environments to virtual communication, or sophisticated participatory cartographic platforms, have made significant contributions towards stakeholder engagement, enabling information

[1] From this work the following publications and deliverables have been achieved:
Markantonatou V, Noguera P, Semitiel-Garcia M, Hogg, K, Sano M, 2016. Social networks and information flow: building the ground for collaborative marine conservation planning in Portofino Marine Protected Area (MPA). Journal of Ocean and Coastal Management, 120: 29-38
Sano M, Markantonatou V, Palma M , Cerrano C, 2013. Report on the results of the stakeholder engagement through the OnLine survey and the participatory workshop in Portofino MPA. Report. Deliverable 5.2.2a, ITN MMMPA Project.

production and knowledge spillovers (Markantonatou et al., 2013a). These tools integrate multi-disciplinary participatory techniques that advance in cost, time and effort compared to typical approaches, due to their ability to instantaneously transfer information disabling distance obstacles (Merrifield et al., 2012). If used properly, ICTs can make relationships appear remarkably robust and may improve the transparency and efficiency of decision-making processes by integrating accurate information from a wide variety of users (Folke et al., 2005).

Successful stakeholder engagement is not always straightforward but depends on building reliable social networks that will assure horizontal and vertical communication between resource users and government authorities (Prell et al., 2008). The nature and characteristics of these links may vary by different factors. For instance, relationships between actors differ in their interpersonal strength depending on the frequency and quality of communication (Valente, 2012). Strength of ties may affect social processes in resource management such as power relations, information sharing and consensus building (Prell et al., 2009). Stakeholder engagement and information flow may also be influenced by the position of actors in the social network, which can be measured using centrality measures (Borgatti et al., 2009). In communication networks, an actor is considered central if he can quickly interact with other stakeholders of the network; hence he has a strategic position through his contacts for receiving or disseminating information that flows within the network in a short time (Borgatti and Everett, 2006; Wasserman and Faust, 1994). Finally, the communication efficiency and access to resources can be influenced by the network's structure. A disproportionate distribution of ties between actors forming a core-periphery structure is commonly noticed in social networks having distinct risks and benefits for building collaborate management. In a core-periphery network a small number of central agents or 'hubs' is more densely connected while others maintain fewer connections (Borgatti and Everett, 1999).

Stakeholder Analysis (SA) and Social Network Analysis (SNA) are complementary methodologies that have been used to provide information and guidance for fostering communication, trust and collective learning in natural resource management (de Nooy, 2013; Prell et al., 2009). SA focuses on the identification and prioritization of stakeholders and their characteristics that may hamper the engagement in order to minimize the effort and risks of success (Reed, 2008). SNA moves one step forward and elucidates relationships among actors developed within a social network. It allows a better understanding of how the position of actors and the structure of the network may promote or hinder collaboration in natural resource governance (Crona and Hubacek, 2010).

This study aims to provide an insight into the social networks' characteristics directly involved in supporting stakeholder engagement for sound governance performance and co-management of resources. Conducted at a time when Portofino MPA considers initiating negotiating plans to expand the reserve that is expected to stimulate oppositions, this case study is of particular interest and relevance as it adds value and recommendations that can support participation and information flow between stakeholders. The study was guided by the following research questions:

1. Has the Portofino MPA's social network the ability to support adequate information flow between actors?

2. Who are the stakeholders with the capacity to act as communication hubs and foster social capital in Portofino MPA's social network?

3. How can stakeholder participation be improved, taking advantage of the benefits of ICTs and the position of actors in the Portofino MPA's social network?

The present study highlights the importance of embedding weak ties, which may augment plurality and equal opportunities for the participation of all actors into the engagement process. This is one of the few attempts to examine the benefits perceived through creating interventions geared towards a combination of different participation strategies for sound governance processes and adaptive management of marine resources. Finally, the fact that Portofino represents a typical case of an MPA where decisions usually stimulate opposition from users makes the methodology and results applicable to MPAs of similar context.

2. Materials and Methods

2.1 Case study: Portofino MPA and past experience in stakeholder engagement

Since the early 60s several environmental associations and agencies have promoted the protection of the marine area surrounding the Promontory of Portofino's regional terrestrial park. Portofino MPA (Fig. 1) was established in 1999 and is one of the smallest MPAs in Italy (total surface 374ha). It hosts a significant number of activities such as yachting, scuba diving, small-scale and sport fishing that were practiced intensively long before the MPA establishment. Salmona and Verardi (2001) described the establishment of Portofino MPA as a long and difficult process that took several years to reach a common consensus. The initial Decree of 6 June 1998 for the establishment of Portofino MPA stimulated strong conflicts and opposition from the local community. One year later, a new Ministerial Decree of 26 April 1999 was established that reduced the boundaries of the designated area and amended some regulations for human activities. Public opposition to the MPA establishment were attributed to the lack of updated information available, limited awareness within the local community regarding the future benefits from the MPA and poor stakeholder participation (Salmona and Verardi, 2001). Inadequate cross-jurisdictional coordination between different administrations (MPA authority and Portofino Regional Park) regarding terrestrial and marine regulation has hampered communication and has resulted in legislation inconsistencies.

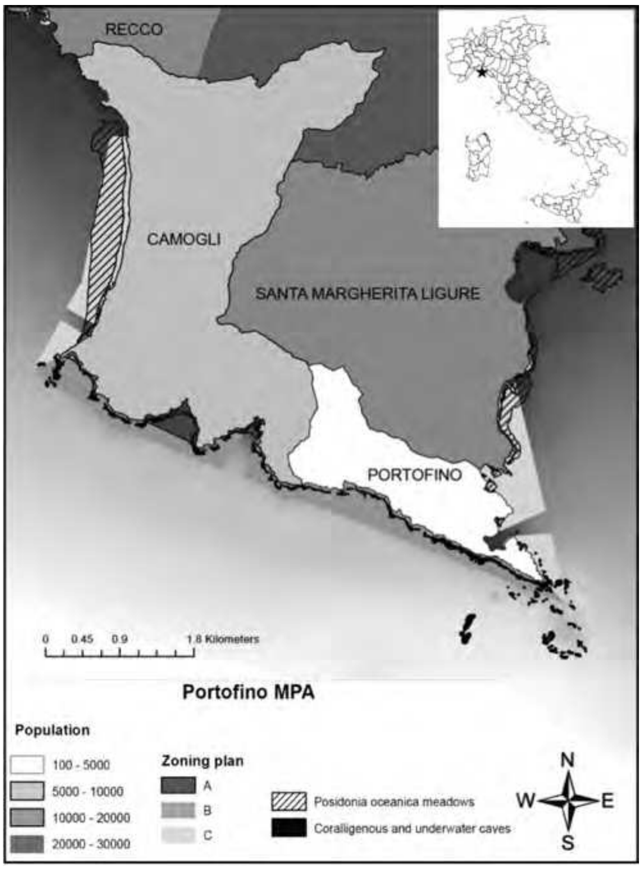

Fig.1. Portofino MPA and the vulnerable coastal habitats it hosts. Habitat map from Diviacco and Coppo (2006, updated to 2012).

One of the future targets of the MPA's management Consortium, consisted of the Municipalities of Camogli, Portofino and Santa Margherita Ligure, the Province of Genova and the University of Genova, is to expand its current area in order to improve its conservation capacity. Past experiences and the current inadequate communication between stakeholders in Portofino MPA suggest that the future conservation initiative is expected to raise conflicts and opposition from the local community, bringing forward new challenges in MPA management (Markantonatou et al., 2013b). Consequently, to increase stakeholder participation and support the planning process, a more effective stakeholder engagement process needs to be carefully designed.

2.2 Survey design and data collection

Semi-structured interviews with key stakeholders in 2013 resulted in the compilation of a preliminary stakeholder list. An online survey was designed to identify stakeholders in Portofino MPA and characterize their relationships. The list was updated using the snowballing technique applied through the survey (Appendix A). In snowballing sampling participants were shown the stakeholder list and were asked to nominate other actors who, from their perspective, should be involved in the management of Portofino MPA. The newly suggested stakeholders were added to the list and were invited via e-mail to participate in the survey. The survey was finalized after four rounds, when snowballing elicited no more new names (Areizaga et al., 2012). The complete stakeholder list includes 56, of which 49 actors were initially identified through the interviews and 7 from the snowballing sampling. Stakeholders were then grouped in 10 categories based on the activities taking place in the MPA (Appendix B). Participants were subsequently asked based on their perception to characterize the strength of their relationship (strong, weak or no tie) with each member in the stakeholder list. To define the boundaries for stakeholder involvement, participants were asked to provide information regarding their current and desired level of participation in Portofino MPA management, and their preferences on communication means for interacting with other actors (Appendix C). The online survey was administered in April 2013 and remained open for one-year. Two rounds of telephone calls and three e-mail notifications were sent to participants to increase the response rate, which reached 82.1% at the end of the survey.

2.3 Data processing and analysis

The relational data were organized into a non-symmetric 56x56 valued adjacency matrix (strong tie = 2, weak tie = 1, no tie = 0). An additional attribute table was created describing stakeholder characteristics regarding current and future participation and their communication preferences. In the case of multiple responses from different individuals representing the same organization, the highest score was selected with the assumption that information flows equally within an organization, as long as at least one of its members is actively involved in MPA management. The role of participants representing more than one organization related to Portofino MPA was selected accordingly.

One of the most easily observed measurement errors in SNA is missing ties according to the true underlying and unobservable structure (Holland and Leinhardt, 1973). Each non-respondent leads to *n-1* missing ties, where *n* is the number of actors in the network. More precisely, for each non-respondent all outgoing ties are missing, while incoming ties are partially observed. Several authors (Costenbader and Valente, 2003; Huisman, 2009; Kossinets, 2006; Stork and Richards, 1992; Žnidaršič et al., 2012) have examined the effects of actor non-response on different network properties in binary networks, such as network density, average vertex degree, and blockmodel structure. In valued networks the effects of missing ties on clustering and valued centrality measures can be found at Žnidaršič et al. (2015a; b). Imputations based on modal values of incoming ties were applied to treat missing ties, as suggested by Žnidaršič et al. (2015a; b) for valued and non-symmetric networks (valued reciprocity equal to 0.29). For each missing outgoing tie x_{ij} $(i \neq j)$ of the non-respondent i, the modal value of all available incoming ties of actor j was imputed. For valued networks, this implies that for the missing tie between non-respondents *i* and actor *j*, the most frequent value of incoming ties for actor *j* (modal value of ties in a column *j*) is imputed.

2.4 Social network measurements

In order to evaluate the network's communication capacity and the role of the weak ties, various network cohesion measures (Borgatti and Everett, 2006; Wasserman and Faust, 1994) were calculated for all ties and strong ties separately: (i) diameter - the longest number of steps between any two actors; (ii) density - the proportion of all possible links present in a network; (iii) average distance - average path length between any two actors; (iv) average degree - average number of ties; and (v) centralization - the extent a network is dominated by single actors.

To understand the way in which information flows in the network and to identify communication hubs or super-spreaders that speed up the diffusion processes, the core-periphery continuous algorithm was applied (Semitiel-García and Noguera-Méndez, 2012). A core-periphery structure may be identified based on the strength of relationship between any two actors as a function of the extent to which each actor is associated with the core (Borgatti and Everett, 1999). In the continuous model, actors are assigned with a 'coreness' value using the correlation measure of fit of the core-periphery model, which quantifies the strength of each actor membership in the core group by measuring the degree of how close the position of each actor is to the core (Rombach et al., 2014). The changes in the ranking position of institutions according to coreness values were examined for all ties and for strong ties, in order to explore how the strength of ties structures the social fabric and the role of each stakeholder category in it.

Identification of stakeholders with the capacity to best assemble and disseminate information, or to accelerate the effect of interventions in the network due to their links, was measured through different centrality measures (Freeman, 1978; Wasserman and Faust, 1994): (i) indegree centrality - the number of connections or ties received by an actor from others; (ii) outdegree centrality - the number of ties given by that actor to the others; (iii) betweenness centrality - the times that an actor rests between two others that are not themselves directly connected to others or are completely disconnected; (iv) closeness - the sum of the distances of an actor to all others. All analyses were conducted using UCINET (Borgatti et al., 2002), and illustrated using PAJEK software (Batagelj and Mrvar, 2003).

3. Results and discussion

3.1 Ability of Portofino MPA's social network to support information flow

The relatively high density of the overall network (Table 1) suggests increased probability that any randomly selected actor is able to receive information that flows in the network through his linkages (Costenbader and Valente, 2003). The high score of average degree and the low scores of distance and diameter confirm that actors may be reached in few steps. Finally, centralization suggests that the network's activity is moderately centered on a few high-degree actors that benefit more with regard to resources, but their presence keeps the network compacted rather than fragmented (Wasserman and Faust, 1994). Taking into account all the cohesion descriptors, we conclude that the Portofino MPA's social network has an adequate capacity to efficiently support information and knowledge flow between stakeholders.

On the contrary, the small number of strong ties (23% of all ties) and the low-density network they form imply limited trust-bonded relationships between actors. Network centralization accounting only for strong ties is lower in comparison to the network of all ties, suggesting the existence of cohesive subgroups, which function as separate entities rather than a unity. Low centralization and limited trust between stakeholders suggest possible risks for the collaboration among subgroups and joined action in natural resource management (Borgatti and Foster, 2003).

Table 1

Measures of cohesion in the social network of Portofino MPA, all and strong ties.

Cohesion measure	All ties	Strong ties
Number of ties	1590	360
Diameter	5	5
Density	0.516	0.117
Average distance	1.508	2.521
Average degree	28.393	6.429
Centralization	0.666	0.500

The outcomes of the analysis underline the importance of weak ties in Portofino MPA's network. Strong ties are solid and are considered trusted suppliers of information, while weak ties hold more diverse opinions and are valuable for accessing or disseminating new ideas across a network (Granovetter, 1973). In Portofino MPA the contribution of weak ties increases the network's cohesion and information flow by creating dense communication channels that allow information to reach all actors. Therefore, the presence of the weak ties should be considered important as they promote deliberation and assure a higher network capacity for long-term planning (Bodin et al., 2011).

3.2 Central communication hubs in the Portofino MPA's social network

In the previous section a cohesive network was identified with the capacity to allow for the flow of information between actors. This section focuses on the core-periphery structure in order to identify highly connected and central actors that can advance stakeholder participation and information flow in the Portofino MPA network (Semitiel-García and Noguera-Méndez, 2012). Considering all ties, the identification of a core-periphery structure (correlation 0.561) provides a discrimination of three components (Fig. 2): a core, a semi-periphery and a periphery.

A highly centralized core, comprised of six actors, includes important stakeholder categories (administration, academy and research, education, diving and professional fishing), whose activities mainly operate in the MPA and are closely linked to the MPA's objectives. Most of them hold central roles in the network due to their links and their position (Table 2). For instance, the institutional actor UNIGE (University of Genova) has a long history of research in the area and is leading the network as the most important recipient of information. The presence of UNIVPM (Polytechnic University of Marche) at the core, even though it is geographically remote, may be explained by the close relationships of some representatives with UNIGE. Due to its contact with isolated actors and other networks, UNIVPM has the capacity to bridge isolated actors in the network ('broker').

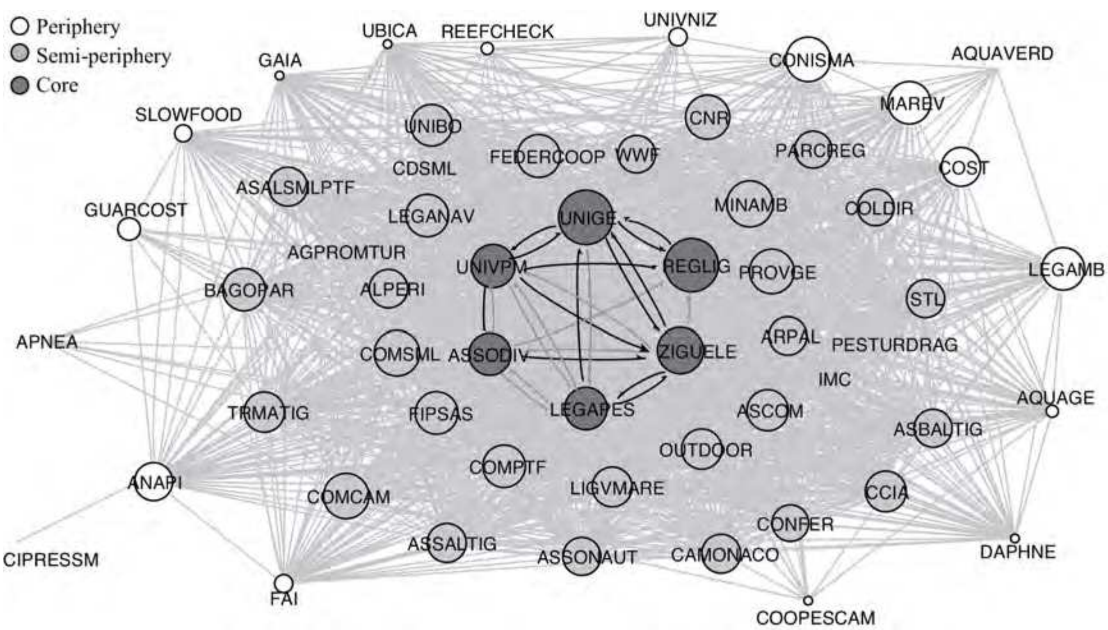

Fig. 2. Complete social network of Portofino MPA. Size of nodes represents indegree centrality, and colour of arrows indicates strong (black) and weak (grey) ties between the core actors.

The formal authority and control that the REGLIG (Liguria Region) has in the wider area could explain the central role of the organization in the network as a leading administration unit. LEGAPES (Fishing League) represents the sustainable economic growth of small-scale fishing, which is the oldest and most traditional activity practiced in the MPA. It has an active input in the management of MPAs in Italy, with the ability to act as a transmitter of knowledge (outdegree) to a wide network of environmental associations and international organizations. The local association ZIGUELE represents the educational activities related to the marine environment and traditional fishing (*'tonarella'*). Even though the association is active in the area, high centrality scores may be also due to the fact that some individuals are closely associated with the MPA. Finally, diving is a key activity with more than 20 diving centers operating in the area, where ASSODIV (Divers Association) represents the majority of them. Divers maintain several communication links with local actors due to their frequent presence in the field and their involvement in several MPA activities. This makes ASSODIV an important transmitter of information to the network. The existing conflicts, competition and limited coordination between diving operators in the area that have emerged due to the recent financial crisis, underlines the necessity for ASSODIV to support information spillovers and increase collaboration within the diving sector.

Table 2

Top 10 actors in centrality terms, normalized values, all ties.

Actors	InDegree	Actors	OutDegree	Actors	Betweenness
UNIGE	82	UNIVPM	61	UNIVPM	9.6
REGLIG	79	AQUAGE	56	LIGVMARE	4
ZIGUELE	59	ASSODIV	54	AQUAGE	3.9
MINAMB	59	LEGAPES	54	COMSML	2.8
COMSML	57	ARPAL	54	UNIGE	2.5
COMCAM	57	DAPHNE	53	ZIGUELE	2.4
PROVGE	55	LIGVMARE	52	MINAMB	2.2
CONISMA	55	OUTDOOR	52	WWF	2.1

See the Appendix A for stakeholder's abbreviations, names and categories.

The core represents the most central stakeholders that pull together the system and may function as communication hubs where information is being funneled through them and diffused throughout most of the system (Borgatti and Everett, 1999). However, there are stakeholders with important benefits for information flow that are currently less involved and therefore are located closer to the margins of the network. The semi-periphery and periphery, compiled by a great diversity of 28 and 22 actors respectively, are characterized by middling or low coreness values. The majority of these groups represent users of the MPA such as recreational fishing and boating, and tourism transportation. The least represented stakeholder group in terms of its low centrality is the recreational activities (AQUAGE, LIGUMARE). The peripheral positions of the institutional Municipalities and the Province of Genova (COMCAM, CAMSML, COMPTF, PROVGE) imply that these actors infrequently interact with each other and with other peripheral actors. Moreover, within the peripheral groups there are central actors that should be more actively involved due to their capacity to bridge, transmit and initiate communication between other actors in the network, such as the Aquarium of Genova (AQUAGE) and the environmental association DAPHNE (Bodin and Crona, 2009). The difference in the nominations from the periphery to the core and vice versa indicates that relationships between the two groups are not perceived as reciprocal, and suggests that peripheral actors are not considered essential elements in the MPA's management by the core. This is verified by the fact that the majority of the peripheral actors are not embedded in the engagement process, since they were not indicated by the MPA board to be involved in the management.

When considering only strong ties the core of the network (Fig. 3) becomes less diverse in terms of stakeholder categories.

The presence of new actors COMCAM and the NGO WWF in the core shows that even though they do not hold so many contacts these relationships are strong and solid. On the contrary, ASSODIV has numerous weak ties but lacks strong relationships hence, the association is missing from the core of strong ties. Results suggest that information flows are centralized between administration and academy/research, as shown by their high partition (50%) in the core. The high closeness centrality scores (not shown here since they are very similar to betweenness) verify the benefits perceived by these groups, as they may independently reach and access newly generated information rapidly due to their high connectedness (Borgatti, 2005). This has important implications for information diffusion process to knowledge of particular actors that are less represented or isolated from the core, such as recreational activities (Bodin and Crona, 2008). High closeness also implies the significance for stakeholders to maintain strong links with administration and researchers in order to obtain information that flows in the network (Ernstson et al., 2008). It is important to point out that the land managers REGLIG and PARCREG were nominated as popular institutions by their high indegree centrality score, yet in practice they are not typically involved in the MPA engagement process. This gap highlights the necessity of collaboration and coordinated actions between the terrestrial and marine agencies, in order to improve management and the sustainable use of coastal and marine resources.

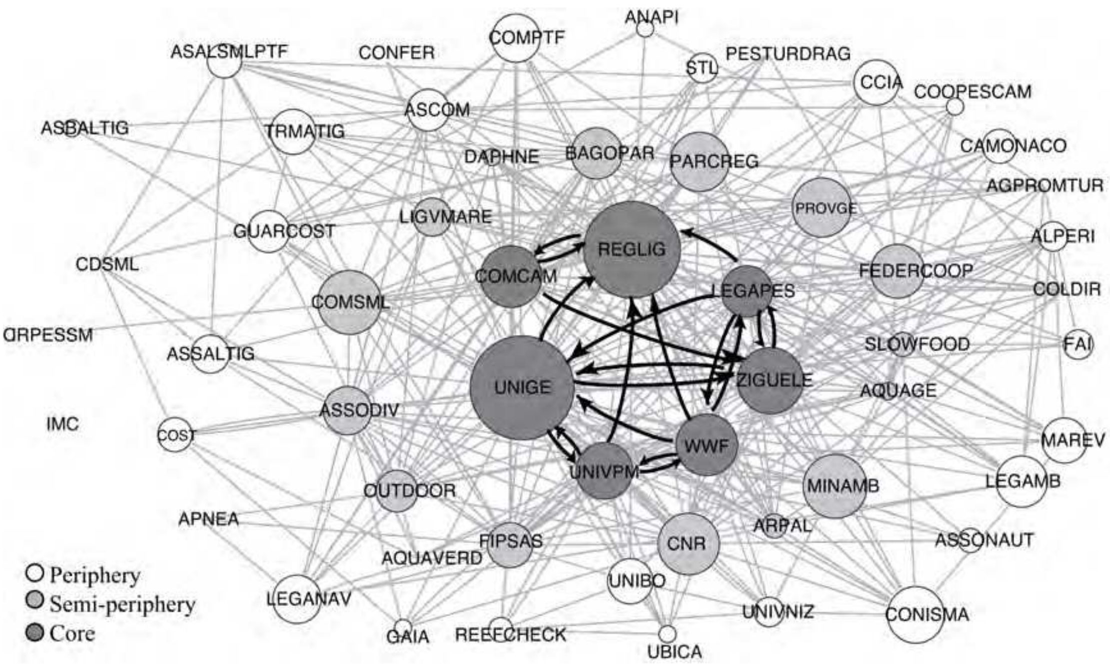

Fig. 3. The core of the social network of Portofino, strong ties. Size of nodes represents indegree centrality.

The comparison of networks of all and strong ties, shows relevant changes in the positions of categories (Table 3). The greatest negative difference in the ranking (ranging from -21 to -15) was mainly in the tourism category (ASBALTIG; ASALMLPTF; ASCOM; CONFER) and recreational boating (ASSONAUT). These outcomes indicate that these actors have fewer strong ties, held mainly with institutions of lower coreness, and verify the current inequalities to information and resource access and the partial representation of some stakeholders when considering all ties. Institutions with the greatest positive differences in ranking position (ranged from 15 to 24) were mainly scientific and academic institutions (CNR, CONISMA, UNIVNIZ), environmental associations (SLOWFOOD, DAPHNE), professional fishing (FEDERCOOP) and administration (COMCAM). These categories are characterized by strong ties with higher coreness actors, and seem to be more central institutions in the MPA management. Nevertheless, in each category there is at least one institution positioned in the core or very close to the core. Finally, in both cases of all and strong ties, actors characterized by positive differences in ranking overlap. This suggests the occurrence of suitable conditions for the participation of these categories through representatives that may facilitate collaborative MPA management.

Table 3

Relevant changes in the positions of stakeholder categories, all and strong ties.

Stakeholder categories	All ties	Strong ties
Research/ Academy	UNIGE (1); UNIVPM (2)	UNIGE (1); UNIVPM (3)
Administration	REGLIG (5)	REGLIG (2)
Diving	ASSODIV (6)	ASSODIV (10)
Env. associations/ NGOs	WWF (17)	WWF (5)
Professional fishing	LEGAPES (3)	LEGAPES (4)
Recreational/ Educational activities	ZIGUELE (4)	ZIGUELE (6)
Recreational fishing	FIPSAS (14)	FIPSAS (9)
Tourism	ASCOM (9)	BAGOPAR (14)

Values in brackets indicate the position of a particular agency in relation to the core.

A core-periphery structure is beneficial for boosting the engagement performance through interventions and knowledge sharing between actors (Bodin et al., 2006) and may provide support at critical moments when decisions need to be made (Bodin and Crona, 2009). The high centrality scores of the core indicate that these stakeholders are potentially in the best position to promote the conservation initiative for the enlargement of the Portofino MPA and lead change by using their power, prominence and widespread contacts (Prell et al., 2009). However, the fact that the core relies on a few strongly linked actors makes the system vulnerable if these actors dysfunction or were to become inactive (Bodin and Crona, 2009).

Furthermore, core actors have considerable power to control other actors' access to multiple sources of information and resources (Wasserman and Faust, 1994). The lack of interaction between the semi-periphery and periphery amplifies the risk of information and resources to circulate only between well connected actors and marginalizing other categories such as recreational activities, tourism and recreational boating (Valente, 2012).

In order to increase the stability of the Portofino MPA's social network and balance power disparities, existing weak ties that determine the observed network structure need to be strengthened. The core- periphery model highlights the ability of weak ties to amplify the network and act as potential channels of communication in order to facilitate super-spreaders for coordinated action and collective learning. In the following section possible ways to increase interaction and communication between core and peripheral actors are examined, that may assure successful stakeholder engagement and adaptive co-management of marine resources in Portofino MPA.

3.3 Facilitating stakeholder participation and the co-production of knowledge through integration of approaches

Simple information transfer is not enough, but current ties and desire for participation must be considered to support stakeholder engagement (Bodin et al., 2011). The results of the questionnaire showed that the current participation level is relatively low and there is a common desire to participate more actively in the management of Portofino MPA. From the 43 actors that responded to the question about their current level of participation in the MPA's management, only a small proportion of actors (21%) perceived that they are actively involved in decisions, or put forward suggestions that are taken into consideration. The majority of them are local stakeholders. The rest claimed that their suggestions are not considered (7%), or that they are informed once decisions have been made (42%), and 30% felt they are not informed at all. A majority of actors (36.4%) wish to be actively involved and responsible for the MPA's management, 18.2% of responders want to make suggestions that are heard, 20% would like to be consulted without their suggestions necessarily being taken into account, and the rest (25.4%) to be informed once decisions have been made. Of the core actors, ZIGUELE and UNIVPM perceive they have not been actively integrated into the system while one third of peripheral actors share the same perception and ask for empowerment in Portofino MPA management, as indicated in Fig. 4 by the bubbles (actors) above the bisector line (dashed).

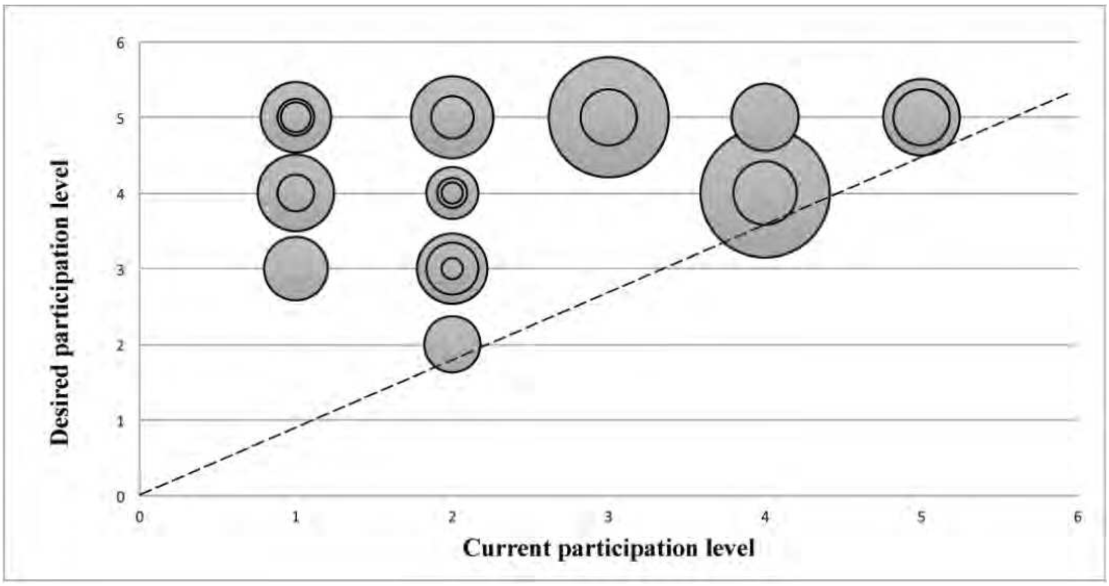

Fig. 4. Current and desired participation in the management of Portofino MPA, the size of the bubbles depicts indegree centrality. The numbers indicate the level of current and desired participation, ranging from 1 (low) to 5 (high) as explained in Appendix C.

Regarding the means of communication, Portofino MPA's actors generally prefer to interact through face-to-face approaches than by using online tools (Fig. 5). A vast majority of stakeholders (71.4%) prefer to communicate through round tables and workshops, 53.6% desire to meet in public events and conferences and 26.8% to discuss through direct telephone calls. The least popular personal communication method (14.3%) was personal interviews. Core actors also show special preference in meetings (100%) and public events (66%). This finding suggests that trust is a key feature in their social relationships implying the importance of more opportunities for face-to-face interactions with others in order to form perceptions and shape actions in Portofino MPA (Cross and Borgatti, 2004). Regarding the use of ICTs (Fig. 5) a vast majority of respondents, including core actors, use more than two web communication tools to interact with each other. The most popular cyber communication is via emails (50%), a common communication mean in working ties, and Social Media (37.5%), mainly preferred by diving operators, environmental associations, NGOs and recreational activities. Preference on Social Media by these specific stakeholder categories confirms the role of these tools in business marketing and conservation awareness for the rapid dissemination of new information to a wide and spatially dispersed audience (Grabowicz et al., 2012; Stelzner, 2014). These results demonstrate that there is some capacity to intensify interactions through the use of ICTs and actively involve marginalized actors that tend to use these tools.

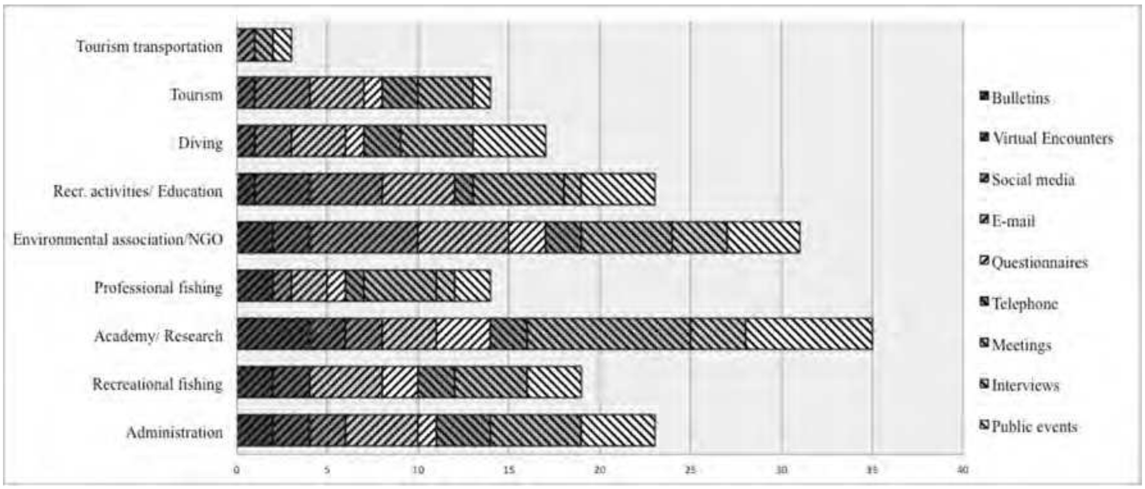

Fig. 5. Preferences in personal and internet-mediated communication between Portofino MPA's stakeholders. Recreational boating did not respond to the question.

Yen and Leskovec (2014) noticed that web networks exhibit a single dominant core that administers information around a common interest or topic, similar to the core-periphery structure in a social network. In Portofino MPA, relevant core actors such as UNIGE[2], REGLIG[3] and MINAMB[4] have developed Web-GIS platforms where ecological and socio-economic data are being made available. Hence, these actors through their portals could coordinate communication, functioning as seeds and spreaders of information. They could encourage the use of ICTs taking advantage of their prestige and ability to reach everyone in the network. Furthermore, administrative institutions and scientific/academic entities have been commonly recognized as trusted sources of information due to their resilient role in resource management, their good knowledge of local conditions and culture, and their long

[2] Marine Coastal Information System, MACISTE: www.remare.org/cartografia-amp-maciste
[3] www.cartografia.regione.liguria.it; www.regione.liguria.it/servizi-on-line/tipologia/cartografia.html
[4] www.pcn.minambiente.it/GN

involvement in the management of the area (Valente, 2012). As a result, the contribution of the core actors may have a positive impact on the willingness to share knowledge, encourage new engagement strategies and mobilize the group for interaction towards a new initiative (Bodin and Crona, 2008; Renzl, 2008).

Empowerment of information transmitters and brokers that are currently less involved is expected to assist in avoiding information bottlenecks and optimize the dissemination of knowledge in the network. Grabowicz et al. (2012) revealed the importance of brokers in the diffusion of information as intermediate users of Social Media, where information received from one group was further disseminated to other groups through re-posting and sharing. Therefore, brokers being familiar with ICTs, such as divers and NGOs, have a central role regarding the transmission of information and norms, and the propagation of online tools to stimulate group actions (Ennett et al., 2006). The involvement of marginalized actors such as tourism and recreational sectors that showed high preference towards web communication rather than personal, could be secured by using online participation tools. Moreover, divers, maritime tourism and professional fishermen that are familiar with computer technologies, such as Global Positioning Systems (GPS), electronic monitoring and/or Vessel Monitoring Systems (VMS), sensors and acoustic data, could contribute to the MPA monitoring by reporting on web platforms geo-referenced information from the field.

The present study suggests that creating technological environments that expand the use of ICTs and integrate e-mail notifications, Social Media characteristics and dynamic mapping services, could be combined with more traditional communication approaches aiding to increase stakeholder interaction for the future decision-making process. Cyber communication may maintain or deepen existing relationships in the social network with frequent online contact (Ellison et al., 2014; Grabowicz et al., 2012; Haythornthwaite, 2005), increase understanding of existing information through visualization, and support low-cost interaction between actors (Markantonatou et al., 2013a). Face-to-face communication on the other hand assists in building of trust between actors (Valente, 2012), which is necessary for the local actors to welcome the new initiative of Portofino MPA enlargement. Existing web platforms should adjust and adapt to accommodate rapidly changing technology, and provide user-friendly interface in order to facilitate effective governance processes and positive environmental outcomes (Glaser et al., 2010). This also implies that core agencies should establish agreements with data providers to ensure open access data. Scientists should be committed to communicate their results to users through trans-disciplinary interaction fostering co-production of knowledge.

There are some exceptional examples of how computer science has responded and offered its services to meet the diverse and complex needs of conservation planning and resource co-management. For instance, the European Commission has adopted web platforms, such as the portal 'Your voice in Europe'[5] for open consultations and discussions with stakeholders regarding policy-related issues. SeaSketch[6] is a WebGIS platform that integrates numerous participatory and comprehensive visualization techniques of multiple information layers. Stakeholders are trained in order to engage by using this tool in marine conservation planning. Participants may add their own geo-referenced information by drawing 'sketches', upload their own datasets, and consult or vote for feature enhancements through interacting elements adopted by Social Media (Markantonatou et al., 2013a). These facts reveal the potential of ICTs to assist managers in Portofino MPA to promote community and social involvement in the management of resources.

4. Conclusions

Administrative and academic institutions had a leading role during the establishment of Portofino MPA. This institutional group progressively expanded showing significant advancement towards the engagement of actors, including the ones that were initially opposed to the MPA's establishment such as the fishing sector. These core actors combine central characteristics of trusted leaders and brokers with a great potential to promote the initiative of Portofino MPA enlargement. They keep the network cohesive and act as central communication hubs with the capacity to collect and disseminate information through their multiple links. While important steps have been made towards the involvement of all stakeholders by the MPA management board, relevant user groups have still a peripheral role or maintain weak relationships between them. This lack of interaction between peripheral actors

[5] http://ec.europa.eu/yourvoice
[6] www.seasketch.org

may pose risks for their access to resources and information (Valente, 2012). Therefore, strengthening of weak ties and promotion of trust between actors are necessary in order to establish stronger communication channels that avoid accumulation of critical knowledge and allow information to flow more readily.

Outcomes indicate weak ties as responsible for the core-periphery structure and the majority of the embeddedness and flexibility to the system, which is particularly critical for conflict resolution and the setting of long-term goals in resource management (Zhang et al., 2015). Lessons from the past showed that information flow in Portofino MPA failed in certain cases to consider all the opinions and opposing sides during the MPA's establishment. It is expected that in a future expansion of the MPA, similar conflicts will emerge that are likely to cancel or postpone the conservation initiative. It has been shown that centralized and dense networks advance in information transmission and management effectiveness. For instance, users of the periphery collected information due to their constant presence in the field, while the centralized core assembled this information in order to further disseminate it and to inform decisions brought from the periphery (Ernstson et al., 2008; Isaac et al., 2007). The collaboration between marine and terrestrial authorities is also expected to improve collective action and conservation efficiency.

Weak ties integrate peripheral actors into the decision making process and create the links between stakeholders in order for information to reach everyone in the network (Carlsson and Berkes, 2005), particularly recreational activities and tourism sectors in this case. Peripheral actors are important to engage because they expand the system and add heterogeneity to the network (Zhang et al., 2015). Strengthening of weak ties may also support the core hubs to widespread information and secure the boundaries of their power to control information or circulate exclusively between them (Granovetter, 1973).

Considering that majority of actors with low participation level desire to be actively engaged in MPA management, a positive impact is expected in governance terms by involving them into decisions and increasing their satisfaction. Along with their familiarity with ICTs, provides important opportunities for managers of Portofino MPA to design a robust and dynamic engagement intervention by coupling online with personal communication strategies. This will assist in creating key conditions for achieving successful stakeholder engagement and designing sound conservation planning. A core-periphery structure benefits the effects of using certain types of computer mediated communication that may involve adaptable participatory techniques and provide an alternative medium to connect actors towards the initiative (Heeks, 1999).

The present study employed a social network perspective in exploring the governance conditions and their implications in information flow that drive stakeholder engagement in natural resource management. This work suggests a simple and low cost methodology for conservation managers and planners to explore alternative forms of dynamic stakeholder participation and collaborative management, taking into account restrictions of time, budgetary constraints and availability of stakeholders to participate with their physical presence. SNA may secure representativeness and deliberation by explicitly including powerful, remote and marginalized actors, support timely and well-informed decision-making, and allow sound governance performance in ocean and coastal management. This work is part of a wider ecosystem-based management approach that considers the social and ecological drivers of the system as complementary components for supporting future conservation initiatives towards collaborative management of resources.

Acknowledgements

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References

Areizaga, J., Sano, M., Medina, R., Juanes, J., 2012. Improving public engagement in ICZM: A practical approach. Journal of environmental management, 109, 123–135.

Batagelj, V., Mrvar, A., 2003. Pajek - Analysis and visualization of large networks, in: Jünger M., Mutzel P. (Eds.), Graph drawing software, mathematics and visualization. Springer Berlin Heidelberg, Berlin, pp. 77–103.

Bodin, Ö., Crona, B.I., Ernstson, H., 2006. Social networks in natural resource management: what is there to learn from a structural perspective? Ecology and Society 11, r2.[online] URL: http://www.ecologyandsociety.org/vol11/iss2/resp2/

Bodin, Ö., Crona, B.I., 2008. Management of natural resources at the community level: exploring the role of social capital and leadership in a rural fishing

community. World Development 36, 2763–2779.
Bodin, Ö., Crona, B.I., 2009. The role of social networks in natural resource governance: what relational patterns make a difference? Global Environmental Change 19, 366–374.
Bodin, Ö., Ramirez-Sanchez, S., Ernstson, H., Prell, C., 2011. A social relational approach to natural resource governance, in: Bodin, Ö., Prell, C. (Eds.), Social networks and natural resource management, uncovering the social fabric of environmental governance. Cambridge University Press, Cambridge, pp. 3–28.
Borgatti, S.P., Everett, M.G., 1999. Models of core/periphery structures. Social Networks 21, 375–395.
Borgatti, S.P., Everett, M.G., Freeman, L.C., 2002. Ucinet 6 for Windows: software for social network analysis. Analytic Technologies, Harvard.
Borgatti, S.P., Foster, P.C., 2003. The network paradigm in organizational research: a review and typology. Journal of Management 29, 991–1013.
Borgatti, S.P., 2005. Centrality and network flows. Social Networks 27, 55-71.
Borgatti, S.P., Everett, M.G., 2006. A graph-theoretic perspective on centrality. Social Networks 28, 466–484.
Borgatti, S.P., Mehra, A., Brass, D.J., Labianca, G.J., 2009. Network analysis in the social sciences. Science 323, 892–895.
Carlsson, L., Berkes, F., 2005. Co-management: concepts and methodological implications. Journal of Environmental Management 75, 65–76.
Costenbader, E., Valente, T.W., 2003. The stability of centrality measures when networks are sampled. Social Networks 25, 283–307.
Crona, B., Hubacek, K., 2010. The right connections: how do social networks lubricate the machinery of natural resource governance? Ecology and Society 15, 18.[online] URL:http://www.ecologyandsociety.org/vol15/iss4/art18/
Cross, R., Borgatti, S.P., 2004. The ties that share: relational characteristics that facilitate information seeking, in Huysman, M.H., Wulf, V. (Eds.), Social capital and IT, MIT Press, Cambridge, pp. 137–162.
de Nooy, W., 2013. Communication in natural resource management: agreement between and disagreement within stakeholder groups. Ecology and Society 18, 44.
Diviacco, G., Coppo, S., 2006. Atlante degli habitat marini della Liguria. Region Liguria, Genova, Italy, pp. 205
Ellison, N.B., Vitak, J., Gray, R., Lampe, C., 2014. Cultivating social resources on social network sites: Facebook relationship maintenance behaviors and their role in social capital processes. Journal of Computer-Mediated Communication 19, 855–870.
Ennett, S.T., Bauman, K.E., Hussong, A., Faris, R., Foshee, V.A., DuRant, R.H., Cai, L., 2006. The peer context of adolescent substance use: findings from social network analysis. Journal of Research on Adolescence 16, 159–186.
Ernstson, H., Sorlin, S., Elmqvist, T., 2008. Social movements and ecosystem services- the role of social network structure in protecting and managing urban green areas in Stockholm. Ecology and Society 13, 39.[online] URL: http://www.ecologyandsociety.org/vol13/iss2/art39/
Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive governance of social-ecological systems. Annual Review of Environment and Resources 30, 441–473.
Freeman, L.C., 1978. Centrality in social networks conceptual clarification. Social Networks 1, 215–239.
Glaser, M., Baitoningsih, W., Ferse, S.C.A., Neil, M., Deswandi, R., 2010. Whose

sustainability? Top-down participation and emergent rules in marine protected area management in Indonesia. Marine Policy 34, 1215–1225.
Grabowicz, P.A., Ramasco, J.J., Moro, E., Pujol, J.M., Eguiluz, V.M., 2012. Social features of online networks: The strength of intermediary ties in online Social Media. PLoS ONE 7, e29358–9.
Granovetter, M., 1973. The strength of weak ties. American Journal of Sociology 78, 1360–1380.
Haythornthwaite, C., 2005. Social networks and Internet connectivity effects. Information, Communication and Society 8, 125–147.
Heeks, R., 1999. Centralised vs. decentralised management of public information systems: a core-periphery solution. Information Systems for public sector management, Working paper series no.7, Institute for Development Policy and Management, Manchester, pp.23
Hogg, K., Noguera-Méndez, P., Semitiel-García, M., Giménez-Casalduero, M., 2013. Marine protected area governance: prospects for co-management in the European Mediterranean. Advances in Oceanography and Limnology 4, 241–259.
Holland, P.W., Leinhardt, S., 1973. The structural implications of measurement error in sociometry. The Journal of Mathematical Sociology 3, 85–111.
Huisman, M., 2009. Imputation of missing network data: some simple procedures. Journal of Social Structure 10, 1529–1227.
Isaac, M.E., Erickson, B.H., Quashie-Sam, S.J., Timmer, V.R., 2007. Transfer of knowledge on agroforestry management practices: the structure of farmer advice networks. Ecology and Society 12, 1–32.
Kossinets, G., 2006. Effects of missing data in social networks. Social Networks 28, 247–268.
Markantonatou, V., Meidinger, M., Sano, M., Oikonomou, E., di Carlo, G., Palma, M., Ponti, M., Cerrano, C., 2013a. Stakeholder participation and the use of web technology for MPA management. Advances in Oceanography and Limnology 4, 260–276.
Markantonatou, V., Sano, M., Cerrano, C., 2013b. Stakeholders, Technology and MPAs: Towards Integrated Management? Proceedings of the Global Congress on ICM: Lessons Learned to Address New Challenges, EMECS 10 – MEDCOAST 2013, Marmaris, 293-–304.
Merrifield, M.S., McClintock, W., Burt, C., Fox, E., Serpa, P., Steinback, C., Gleason, M., 2012. MarineMap: A web-based platform for collaborative marine protected area planning, Ocean and Coastal Management 74, 67–76.
Ostrom, E., 1990. Governing the commons, Cambridge University Press, Cambridge.
Pomeroy, R., Douvere, F., 2008. The engagement of stakeholders in the marine spatial planning process. Marine Policy 32, 816–822.
Prell, C., Hubacek, K., Quinn, C.H., Reed, M.S., 2008. "Who's in the network?" When stakeholders influence data analysis. Systemic Practice and Action Research 21, 443–458.
Prell, C., Hubacek, K., Reed, M.S., 2009. Stakeholder analysis and social network analysis in natural resource management. Society and Natural Resources 22, 501–518.
Reed, M.S., 2008. Stakeholder participation for environmental management: a literature review. Biological Conservation 141, 2417–2431.
Renzl, B., 2008. Trust in management and knowledge sharing: the mediating effects of fear and knowledge documentation. Omega 36, 206–220.
Rombach, M.P., Porter, M.A., Fowler, J.H., Mucha, P.J., 2014. Core-periphery

structure in networks. SIAM Journal on Applied Mathematics 74, 167–190.
Salmona, P., Verardi, D., 2001. The marine protected area of Portofino, Italy: a difficult balance. Ocean and Coastal Management 44, 39–60.
Semitiel-García, M., Noguera-Méndez, P., 2012. The structure of inter-industry systems and the diffusion of innovations: the case of Spain. Technological Forecasting and Social Change 79, 1548–1567.
Stelzner, M.A., 2014. Social Media marketing industry report. Accessed April 26, 2015. URL: www.socialmediaexaminer.com/SocialMediaMarketingIndustryReport2014.pdf
Stork, D., Richards, W.D., 1992. Non respondents in communication network studies: problems and possibilities. Group and Organization Management 17, 193–209.
Valente, T.W., 2012. Network interventions. Science 337, 49–53.
Wasserman, S., Faust, K., 1994. Social network analysis: methods and applications, second ed. Cambridge University Press, New York and Cambridge.
Yen, J., Leskovec, J., 2014. Overlapping communities explain core–periphery organization of networks, Proceedings of the IEEE 102, 1892–1902.
Zhang, X., Martin, T., Newman, M.E.J., 2015. Identification of core-periphery structure in networks. Physical Review E, 91, 032803.
Žnidaršič, A., Ferligoj, A., Doreian, P., 2012. Non-response in social networks: The impact of different non-response treatments on the stability of blockmodels. Social Networks 34, 438–450.
Žnidaršič, A., Doreian, P., Ferligoj, A., 2015a. Actor non-response in valued social networks: The impact of different non-response treatments on the stability of indirect blockmodels. *Submitted.*
Žnidaršič, A., Doreian, P., Ferligoj, A., 2015b. The impact of actor non-response treatments on the robustness of valued centrality measures. *Submitted.*

Chapter III

Spatial allocation of fishing activity on coralligenous habitats in Portofino MPA (Liguria, Italy)

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Abstract

Small scale and recreational fisheries monitoring and management an important challenge that coastal MPAs have to encounter, from a socio-economical, cultural and ecological point of view. The difficulty in monitoring these activities is mainly due to the fact that on the one hand, small-scale fishing shows strong heterogeneity combining different gears and targeting species throughout the year, whilst on the other hand, there is a great number of recreational fishers with several access points by boat or by shore to fish, using a variety of tools that can be adjusted depending on the practice. Understanding the spatial and temporal patterns of fishing effort is fundamental for making informed management decisions for sound conservation of benthic ecosystems and sustainable exploitation of fish stocks. The present study provides a step-by-step approach for monitoring and mapping spatial and temporal patterns of artisanal and recreational fishing activity. Simple spatial indicators and analysis are suggested in order to describe fishing pressure and identify areas that receive the greatest fishing effort, using as an example Portofino MPA (Ligurian sea, Italy). The approach integrates information originating from a range of monitoring strategies that may be adopted depending on the capacity of MPA management performance, and incorporates uncertainty regarding available information following the precautionary principle. In addition, prerequisite information such as bathymetry and distribution of habitats, and combination of monitoring strategies is suggested for increasing the confidence on spatial allocation of fishing activity. Produced results may provide baseline information for the identification of fishing metiérs, ecological modelling, stock assessments and conservation planning.

Key-words

Coralligenous habitats; spatial analysis; fishing effort; resource management; Marine Protected Area

1. Introduction[1]

Fishing activity is considered a significant threat due to the exploitation of fish stocks and the degradation of marine ecosystems. In addition, intensive fishing may alter the benthic habitats' health status directly through species removal, mechanical destruction and abrasion, or indirectly from the re-suspension of sediments, change in habitat type or morphology, lost fishing gear (Bo et al., 2014; Gilman, 2015). Monitoring and management of small scale and recreational fisheries is one of the most important challenges that coastal MPAs have to encounter from a socio-economical, cultural and ecological point of view. Although artisanal and recreational fishing are regulated in most Marine Protected Areas (MPAs) these activities should not be underestimated due to the considerable numbers of fishermen they involve (Font et al., 2012). Small-scale fishing (coastal local activity involving small capital investment and small boats - length ≤12m) represents 86% of all fishing boats (approximately 42,000 boats) in the Mediterranean offering more than 100.000 direct jobs in 20 EU coastal Member States (Maynou et al., 2013; 2011). Small-scale fishers are a particular user group of marine resources, from a socio-economical, cultural and ecological point of view. Artisanal fishing is privileged to operate in some of the richest coastal areas and most vulnerable marine habitats that are physically or functionally fragile, easily disturbed and very slow to recover, such a *Posidonia oceanica* meadows, rocky reefs or corals (FAO, 2009). Conflicts of small-scale fishermen have been frequently reported with commercial and recreational fishing over fishing resources and rights (Maynou et al., 2013). Problems in communication have been also described with other user groups and conservationists (Salmona and Verardi, 2001). Moreover, monitoring of artisanal fishing in the Mediterranean has been characterized as a challenging process that requires complicated approaches due

[1] From this work the following publications and deliverables were achieved:
Markantonatou, V., Marconi, M., Cappanera, V., Campodonico, P., Bavestrello, A., Cattaneo-Vietti, R., Papadopoulou, N., Smith, C., Cerrano, C., 2014. Spatial allocation of fishing activity on coralligenous habitats in Portofino MPA (Liguria, Italy), in: Bouafif, C., Langar, H., Ouerghi, A. (Eds.). Presented at the UNEP/MAP- RAC/SPA, Proceedings of the second Mediterranean Symposium on the conservation of Coralligenous and other Calcareous Bio-Concretions. Portorož, Slovenia, 29-30 October 2014, Portorož, Slovenia, pp. 118–123.
Markantonatou, V., Marconi, M., Cerrano, C., 2015. Guidelines for monitoring pressure and impacts from small scale and recreational fishing activity in Mediterranean Marine Protected Areas, ITM MMMPA project Deliverable D5.2.4, Ancona.

to the strong temporal heterogeneity of the activity, the combination or modification of gears, the variation of tactics depending on the target species and poor data availability (Freire and García-Allut, 2000; Markantonatou et al., 2014).

Recreational fishing represents more than 10% of the total production in Mediterranean (EU, 2004). It is considered, at least in some countries, more privileged, regarding legislation prohibitions and control in comparison to any other type of fishing. It has been estimated that total expenditure on recreational fishing is over 25 billion euros with more than 10 million recreational fishers in Europe (Dillon, 2004; Gaudin and De Young, 2007). The difficulty in monitoring recreational fishing is mainly due to the great number of recreational fishers with several access points, by boat or on the shore using a variety of gears that can be adjusted depending on the practice (Font et al., 2012).

A knowledge of spatial and temporal allocation of fishing effort is fundamental for understanding the impacts from the activity on vulnerable habitats and seafloor integrity (Markantonatou et al., 2014; 2015; Stelzenmüller et al., 2008). Particularly in Marine Protected Areas (MPAs), continuous monitoring and understanding on the spatial distribution of pressures and their potential risks towards reaching the MPA targets is essential. Several approaches have been suggested to monitor fishing activity (Fig. 1) and improve the understanding of the spatio-temporal patterns of fleet and effort, such as the métiers that describe fisheries with regard to fishing gear used, main target species, fishing area and season (Katsanevakis et al., 2010; Tzanatos et al., 2013), or indicators measuring the level of fishing intensity and extent of the habitat, using spatial analysis tools (e.g. (Piet and Hintzen, 2012; Stelzenmüller et al., 2008). The selection however of a monitoring approach highly depends on the MPA capacity, such as human and financial resources, trust-bond relationships with fishers and relevant port authorities.

We present a cost-efficient and flexible monitoring protocol that may ensure successful spatial allocation of artisanal and recreational fishing activity on a scale relevant to current environmental policy. The present monitoring guidelines focus on the long-term monitoring of the recreational and artisanal fishing effort. This information has the potential to be elaborated into further analysis and provide answers addressing sound management decisions for reaching a balance between human activities and conservation. This is part of a holistic ecosystem-based management approach that aims to inform marine resource managers regarding fishing activity and conservation objectives, and is complementary to the approach applied by Prato et al. (in prep.) regarding fishing catch and the impact of fisheries on marine food-webs and ecosystem functioning.

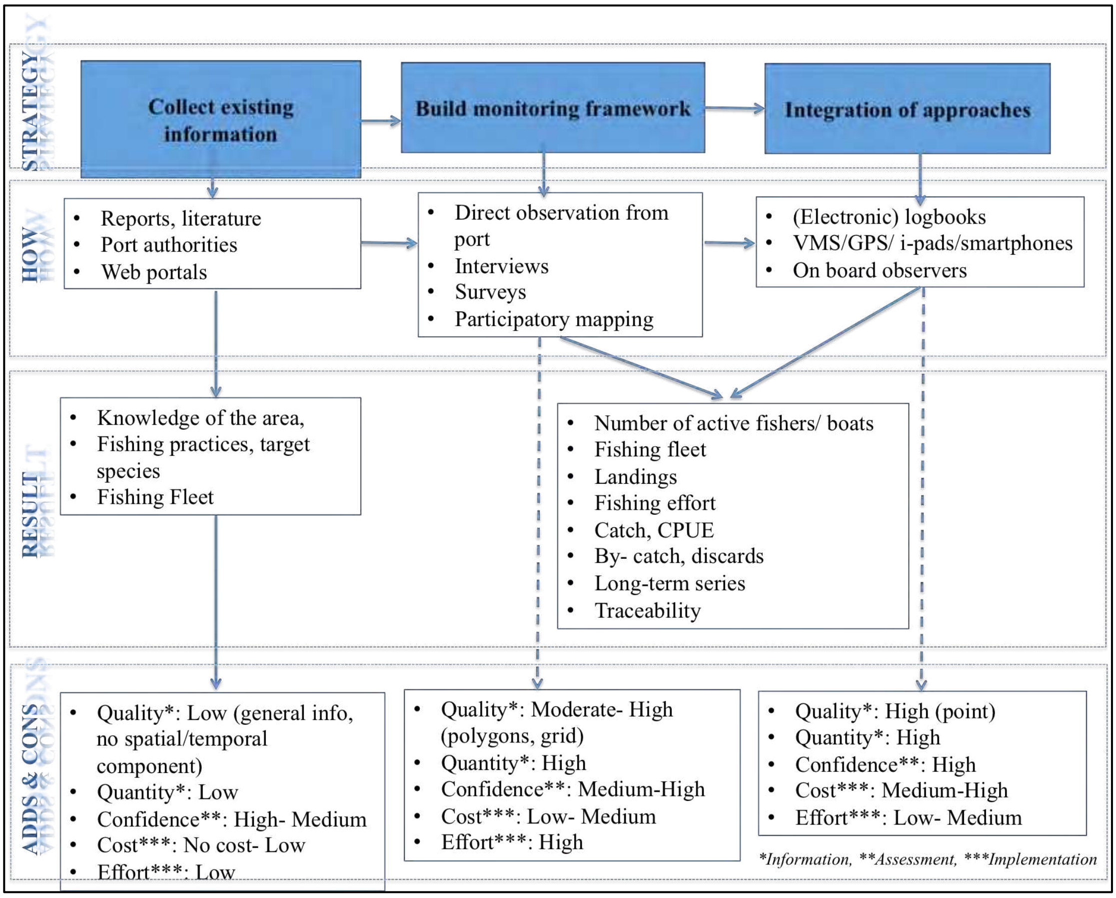

Figure 1. Monitoring frameworks, sources of information, advantages and disadvantages of each monitoring strategy. Source: Markantonatou et al., 2015.

2. Case study: Portofino MPA (Ligurian Sea, Italy)

The Portofino MPA (Fig. 2), established in 1999, is the third smallest Italian MPA (3.74 km^2). In 2005 it has been registered as a Specially Protected Area of Mediterranean Importance (SPAMI), in part due the presence of coralligenous habitats and other key structural species. Fishing activities are regulated and monitored by the MPA management board in close collaboration with the Italian Coastguard and the University of Genova.

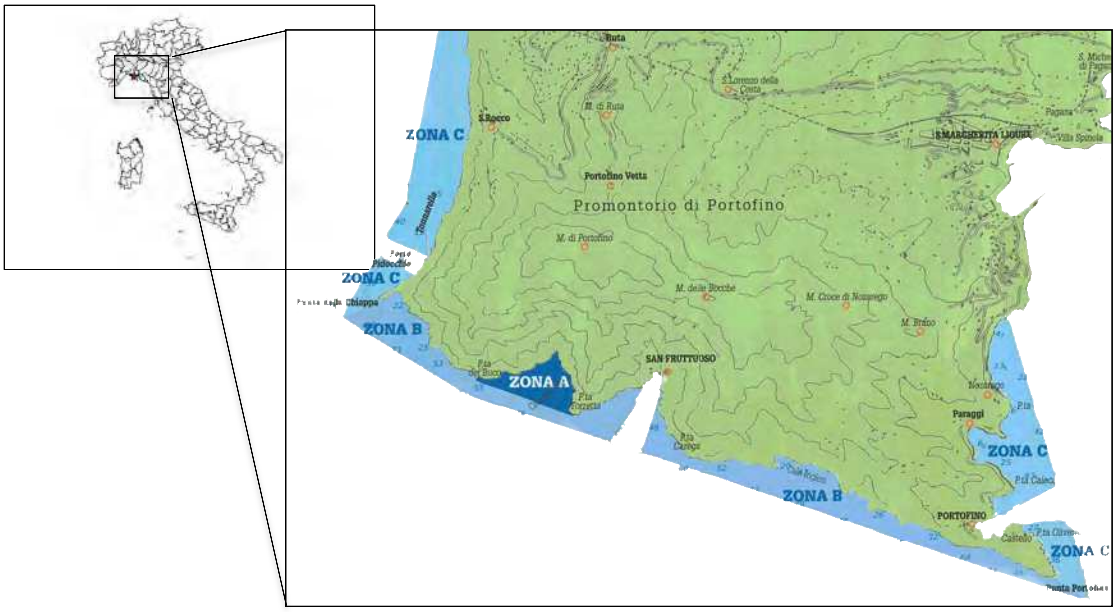

Figure 2. Portofino Marine Protected Area (Liguria Sea, Italy)

Artisanal fishing is allowed only for the residents of the three institutional municipalities (Portofino, Santa Margherita Ligure and Camogli), the majority of which are based in Camogli (70%). Recreational fishing is permitted under authorization in Zones B and C for residents of the three municipalities and in Zone C for non-residents that pay a fee in order to receive authorization (Figure 2). Recreational longlines, trolling and *"natelli"*[2] are regulated through a fixed number of 120 authorizations, including 80 nominal individual fishermen and 40 from recreational fishing associations. Fishermen that practice these activities are obliged to deliver a fishing diary at the end of the year. It is estimated that including the fishers that do not provide a logbook, there are about 350 recreational fishers operating in the MPA (P. Campodonico, pers. comm.). Spearfishing is prohibited throughout the MPA. For both recreational and artisanal fishing several other regulations are in force within the MPA, such as the fishing of certain species (e.g. grouper), seasonal closures (e.g. longlines), prohibitions of fishing techniques and gear modifications, limitation of fishing effort and catch, in order to control these activities.

3. Materials and methods

The MPA has been divided into 18 smaller management units for monitoring

[2] Rings of cork with two nylon lines a few inches long hanging, each of which is armed with a hook; target pelagic species such as *Oblada melanoura*; Font et al., 2012

convenience. Data on fishing activity were obtained by fishing diaries, interviews and mental mapping with fishermen of the Portofino MPA during the period 2011-2015 (Canella, 2012; Mariotti, 2012; Markantonatou et al., 2014; present study). The protocol used during the interviews was adopted from Table 1.

Table 1. Suggested monitoring framework for recreational and artisanal fishing effort

Fishing feature	How to obtain the information	Outcome
Fisherman & boat name **Port registered** **License number** **Distance from coast (license)** **Boat characteristics (length, LFT, GRT, engine power, engine type)**	EU Fleet Database (http://ec.europa.eu/fisheries/fleet) Coastguard Port authorities	Authorized maximum distance from coast; mapping information when spatial information is absent Fleet description Introduction of non-synthetic compounds (gasoline, oil etc.)
Number of personnel **Salary of personnel** **Nationality of personnel** **Total expenses per year (license, fuel, personnel, gears etc.)**	Interviews Coastguard Port authorities	Labor market Socio-economic, cost-benefit analysis
Fishing ground **(area, depth, distance from coast, substrate type, habitat type)**	Indicate on map all fishing grounds Use GPS (coordinates of position of net - start and end point of net deployment) #	Fishing grounds Mapping accuracy
Fishing gear(s)*/techniques**	Indicate gears in every fishing ground Show a list of fishing practices**	Gear footprints
Gear features	Net height and length, material* Line length, number and size of hooks, bait (lines) Number of traps, type, surface, bait	Mapping accuracy Wear resistance Force of gear practice & retrieval Invasive species (bait)
Months per year	Indicate in every fishing ground per gear, or provide % from total in every area	Fishing effort (per month, per season, per year) Fishing effort (days, trips, hours)
Days per month		
Fishing trips per day		
Number of gears/ hauls per trip		
Hours of gear active **Date & time of gear deployment & retrieval#**		
Additional questions **-Dimension of mesh size, hooks, traps etc.**	Indicate per fishing ground Collect information on prices	Catch (Aver. kg/year, CPUE) Mapping of species

-Main catch (target species, number individuals, aver. kg/month) **- Bait used** **-By catch, discards (species, number individuals, aver. size)** **-Trace of catch (restaurants, local market, direct selling, personal consumption)** **- Cost (fuels, gears, licenses etc.)**	from fishermen and restaurants, market	Evaluation of fish population status Trophic food web (see Prato et al., 2015) Socio-economic, cost-benefit analysis

Asterisks refer specifically to artisanal (*) or recreational fishing (**), while # refers particularly to on board or logbook information.

Information from 24 artisanal and 247 recreational fishermen currently active in the MPA was mapped using ArcGIS (10.2) software and cell size of 1 by 1 m^2. Bathymetry, a prerequisite layer for mapping fisheries, was created through interpolation using bathymetric lines and the DEM produced by Zapata-Ramirez et al. (*in prep.*). The habitats map layer was retrieved from Diviacco and Coppo (2006; updated in 2012). Management and local regulations of the wider area (e.g. fishing closures) were also integrated in the mapping of the activity.

Spatial allocation of fishing activity was based on integration of heterogeneous data: (i) GPS points indicating the position of the nets and fishing trip routes; (ii) common fishing depth; (iii) distance from coast; (iv) bottom type; (v) participatory maps; (vi) use of Google Earth to locate areas with access from the coast (Giakoumi et al., 2013; Markantonatou et al., 2014; Mazor et al., 2014). In the case of artisanal fishing, accounting for uncertainty of the nets' location, the spatial deviation equal to 10% of the net length was drawn around the location of gear deployment (Stelzenmüller et al., 2008). Confidence levels were defined by assessing the quality and quantity of information following the precautionary principle. Fishing effort was expressed in total number of hours per season and per year (Fig. 3). We superimposed grids with 1 m^2 cell sizes and aggregated all fishing effort by the sum total of hours per season and per year for each fishing practice. Trends from past information were used as complementary information in order to understand the evolution of the activity in time and the emergence of possible management responses.

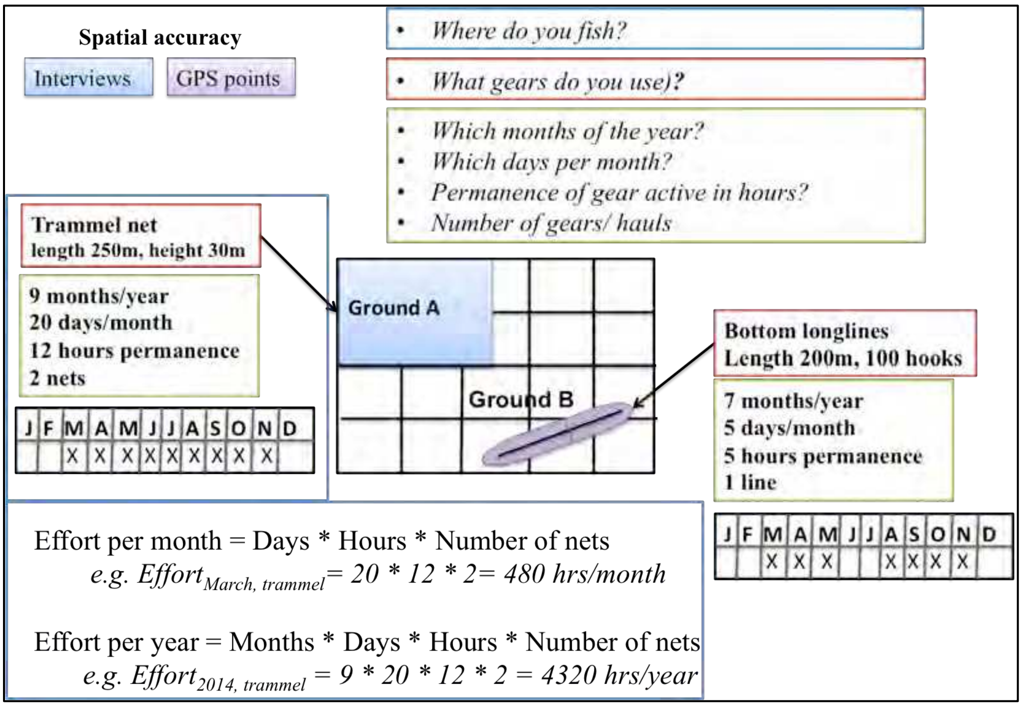

Figure 3. Example of minimum information necessary for spatial allocation of fishing activity. The difference in quality of information between area (interviews) vs. point information (e.g. GPS, VMS, boat observers) is also depicted.

4. Results

4.1 Description of small-scale fishing activity in Portofino MPA

The artisanal fishing sector of the Portofino MPA represents a typical northwestern Mediterranean coastal fishery with a mean boat size of <10m and engine power <75kW (Leleu et al., 2014). Although other studies regarding the monitoring of fishing effort (e.g. (Cadiou et al., 2009; Leleu et al., 2014) do not allow the comparison of results at the same unit of accuracy, information on the number of boats within the MPA suggests that Portofino MPA artisanal fishing has a medium-small fishing status. The maximum fishing effort per cell was estimated approximately in 40,000 hours (Fig. 4) with highest effort located outside the MPA in the Tigulio Gulf. Inside the MPA, maximum fishing effort was recorded in management units 6-11, where mainly fishing nets are operating. Artisanal fishing is rather limited but locally intensive in some cases. The trends over the last years have shown that the activity is decreasing. Therefore in the near future the activity will probably reach a minimum close to zero, as is slowly happening to the Cabo de Palos-Isla Hormingas MPA (Esperanza Alaminos, 2010). The use of artisanal gears is highly seasonal with gillnets, combined nets and fishing cephalopods mostly employed during autumn. During spring and summer, the use of trammel nets and longlines increases. Data from on board observers and interviews also indicated incidents of fishing within the no-take zone.

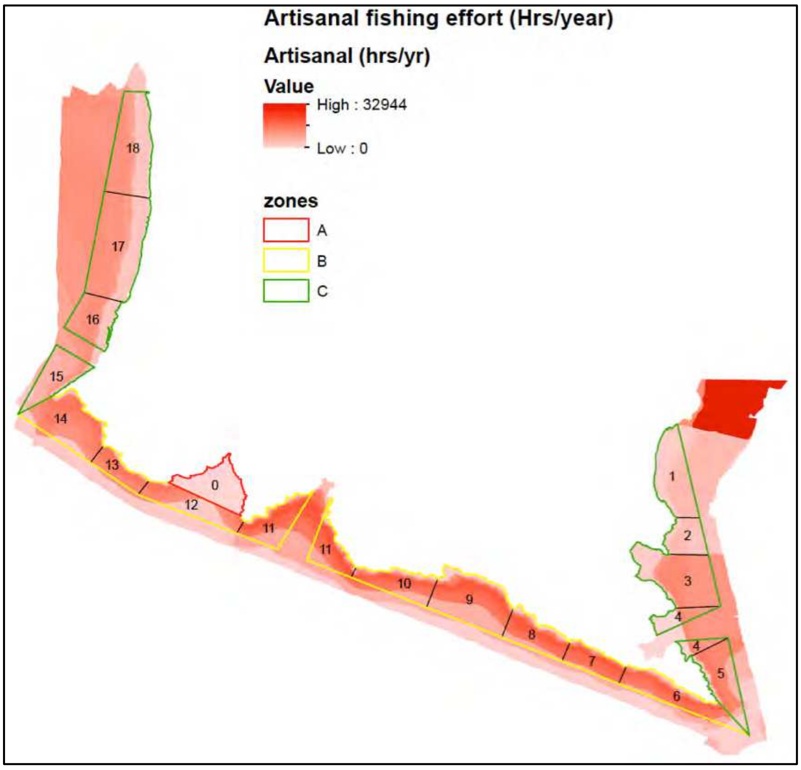

Figure 4. Spatial allocation of small scale fishing activity in the Portofino MPA (year 2015)

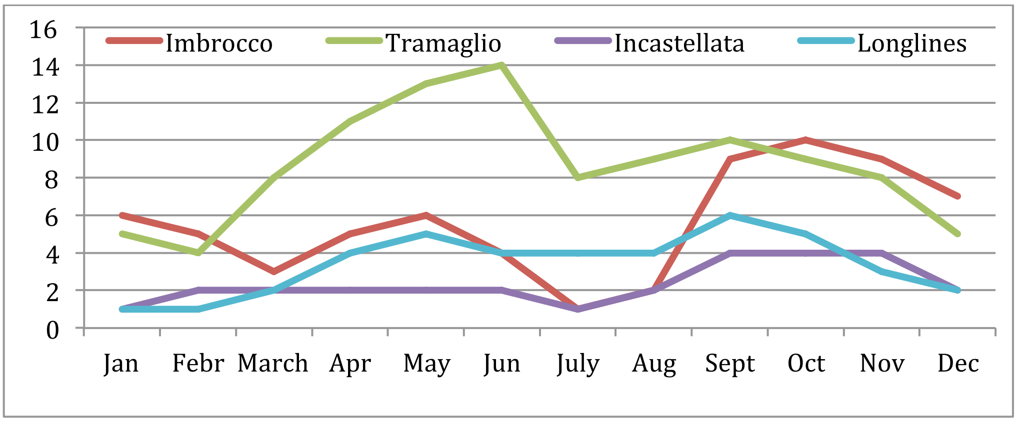

Figure 5. Seasonal variation of small scale fishing activity in the Portofino MPA.

Information on landings was scarce and did not allow accurate computations of fishing catch. From the interviews, however, at least the main target species could be identified (Fig. 6). The most dominant gear in terms of target catch were trammel nets, that in general are very common in the area. More information on the catch may be found in (Prato et al., in prep.). The mapping accuracy of the small-scale fishing was evaluated as high, due to the quality and quantity of information provided by the onboard observers, logbooks and the interviews.

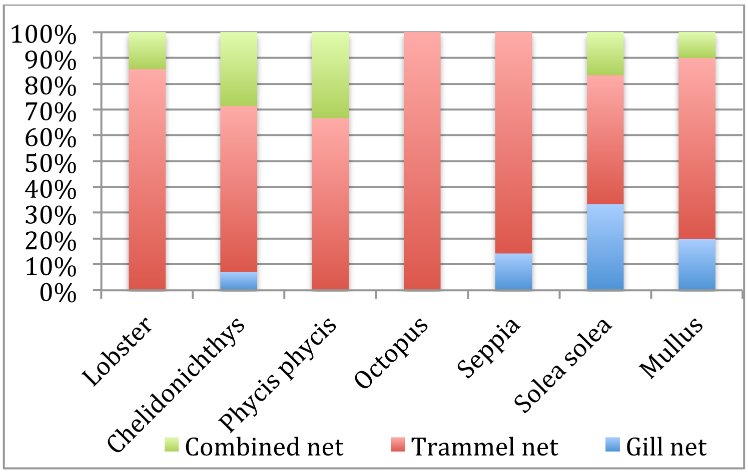

Figure 6. Seasonal variation of target catch species/groups from small-scale fishing in the Portofino MPA, based on general information from interviews.

4.2 Description of recreational fishing activity in Portofino MPA

Recreational fishing activity has been assessed as high (Cappanera et al., 2012), with maximum value of 10682 hours/year/m^2 in management units 1-4 and 13-14 (Fig. 7).

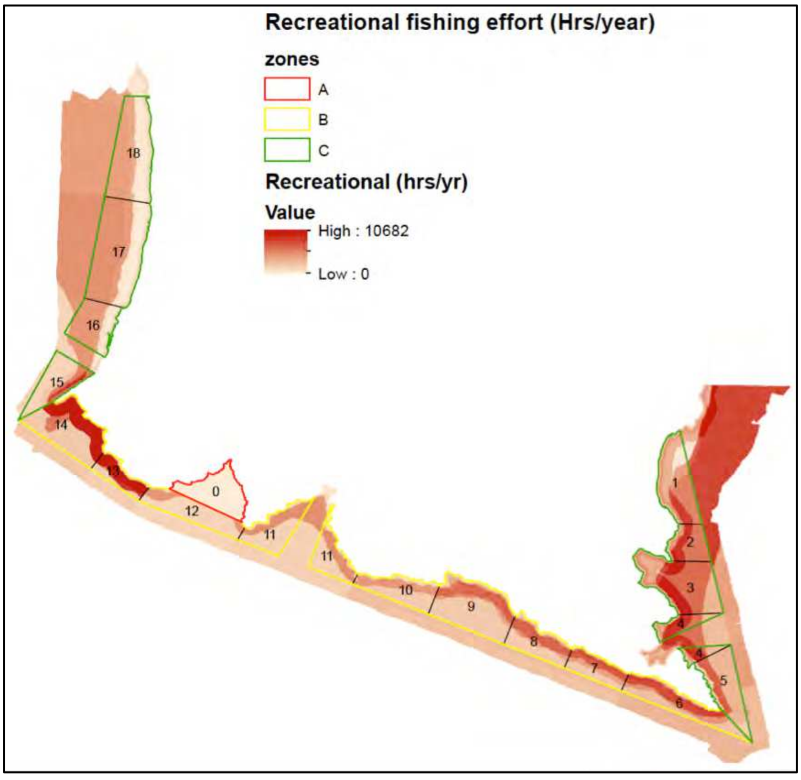

Figure 7. Spatial allocation of recreational fishing activity in the Portofino MPA (year 2012)

Results are confirmed by previous studies that have reported consistent loss of lines and weights from recreational gears in the area around Punta Chiappa (management units 13-14; Cattaneo-Vietti R., pers. comm.). The most popular fishing practices from the shore were the spinning (max 2183 hours/cell/year) and surfcasting (max 1010 hours/cell/year), while from recreational vessels it was handlines for large fish (2313 hours/ cell/ year), followed by handline fishing of cephalopods (max 863 hours/ cell/ year). October was the most popular month for recreational fishing, although there are variations in the seasonal preference depending on the different fishermen groups (residents, fishing associations and non residents) as shown in Fig. 8. The trend of recreational fishing seems to be increasing since 2008 (Fig. 9; Cappanera et al., 2012), indicating possible increase or steadily high pressure from the activity.

Although the information was incomplete regarding the recreational fishers' representativeness in the area and point information was not available, the integration of information in addition to the fact that the MPA is a small area, increased significantly the mapping quality of the activity. In the future, more accurate monitoring of fishing activity by the MPA Consortium, particularly for recreational fishing, is expected to improve the present analysis.

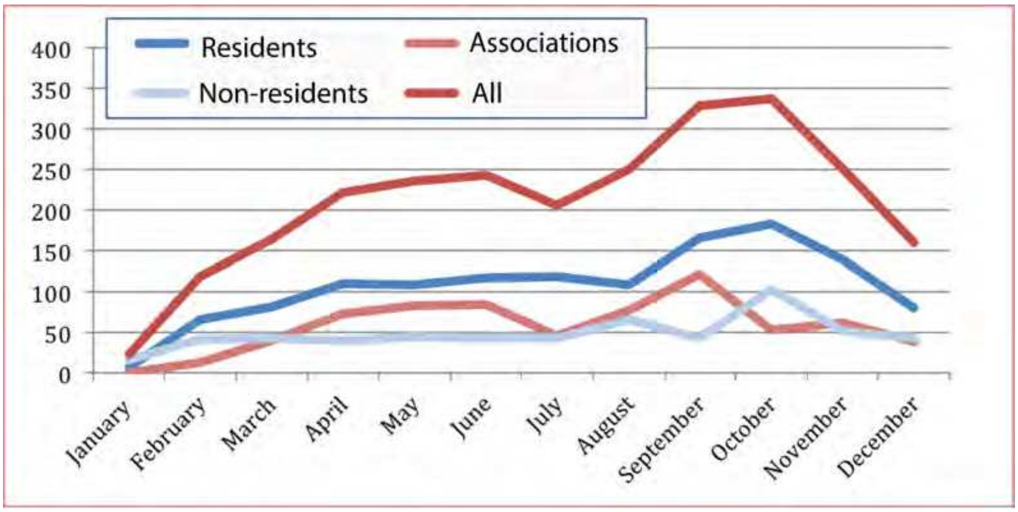

Figure 8. Seasonal variation of recreational fishing (2011) in the Portofino MPA by different groups of fishermen, and total number of recreational fishermen ('All')

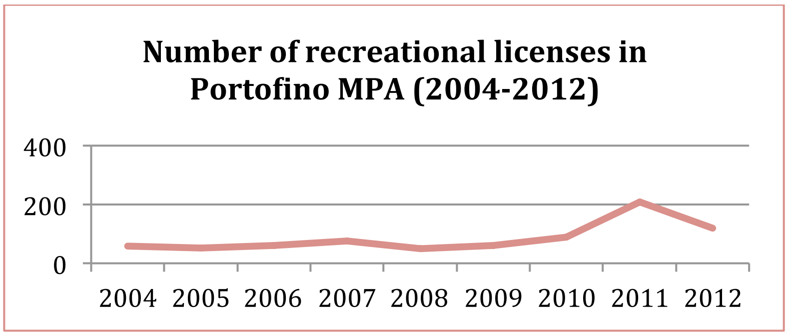

Figure 9. Annual trend for recreational fishing licenses in the Portofino MPA

4.3 Variation of total fishing effort in the Portofino MPA

The aggregated recreational and artisanal fishing effort resulted in the estimation of total fishing effort by summing total hours per year for each tool (Fig. 10). Maximum total fishing effort (approximately 40,000 hrs/year^{-1}*m^{-2}) was allocated in areas outside the MPA (Tigulio Gulf) that is a well-known fishing ground in the Liguria region. However, inside the MPA the major fishing effort is located in management units 13-14 (mainly from recreational fishing) and 6-8 (mainly from artisanal fishing).

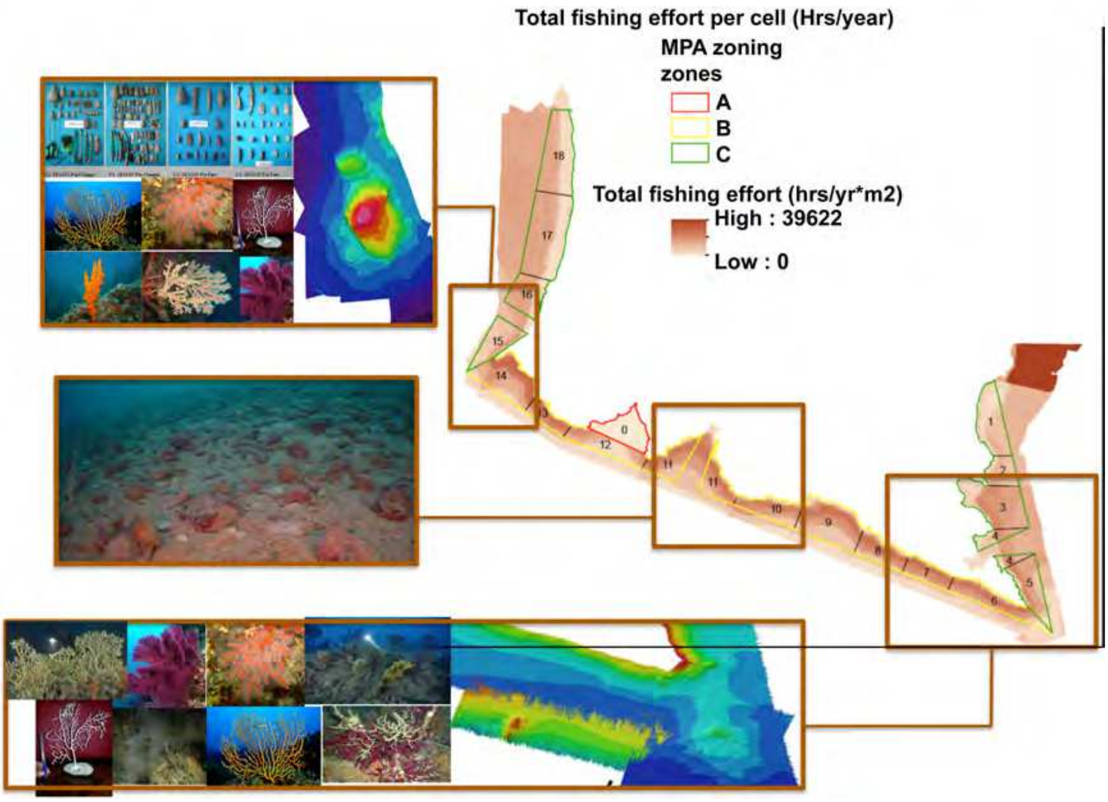

Figure 10. Spatial allocation of total fishing effort (hours per year) in the Portofino MPA (year 2015)

5. Guidelines for monitoring fishing in MPAs

Fisheries resource managers are seeking for integrated approaches that capture the heterogeneity of the fishing activity and provide a better understanding of the spatio-temporal patterns of fleet and effort using spatial analysis tools (e.g. (Stelzenmüller et al., 2008). Aspects such as inspection, the degree to which fishermen accept and comply with regulations and economic resources available, are all key elements in the effectiveness of each MPA (Font et al., 2012). Understanding the spatial and temporal patterns of fishing effort is fundamental for the sound conservation of fish stocks, habitats and seafloor integrity, identification of conflicts and cumulative impacts in resource management. The present study provides a straightforward approach for monitoring and mapping spatial and temporal patterns of artisanal and recreational fishing activity and is applicable to other ecosystems in a wide range of locations.

The adoption of more than one monitoring strategy, for example, logbooks (systematic monitoring) and interviews and/or questionnaires (once per year, or more frequently), is suggested in order to ensure efficient monitoring data in terms of quantity and quality (Markantonatou et al., 2015). Trained MPA staff and students, experienced researchers and relevant port authorities may collect field information through the establishment of agreements or collaborations in research projects for monitoring. Data can also be collected through advanced web tools (e.g. SeaSketch[3], OceanMapTool[4]), mobile apps (e.g. DONIA[5]) or administered accurate real-time GPS location data services transmitted through satellites (AIS, VMS, Marine Traffic[6]), although the cost increases tremendously considering that the MPA should provide smartphones or tablets and Internet access (Markantonatou et al., 2013; Meidinger et al., 2013). Moreover, the average age of fishermen in several Mediterranean countries is a barrier to the use of high technology unless proper training is offered. In any case new technologies for fisheries data collection allow for progress not only in accurate data providence, but also assisting in locating illegal fishing and violations (e.g. Global Fishing Watch[7]).

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[3] www.seasketch.org, *McClintock lab, University of California Santa Barbara*
[4] www.ecotrust.org
[5] www.donia.fr, *Andromède Océanologie*
[6] www.marinetraffic.org
[7] http://globalfishingwatch.org, *Oceana*

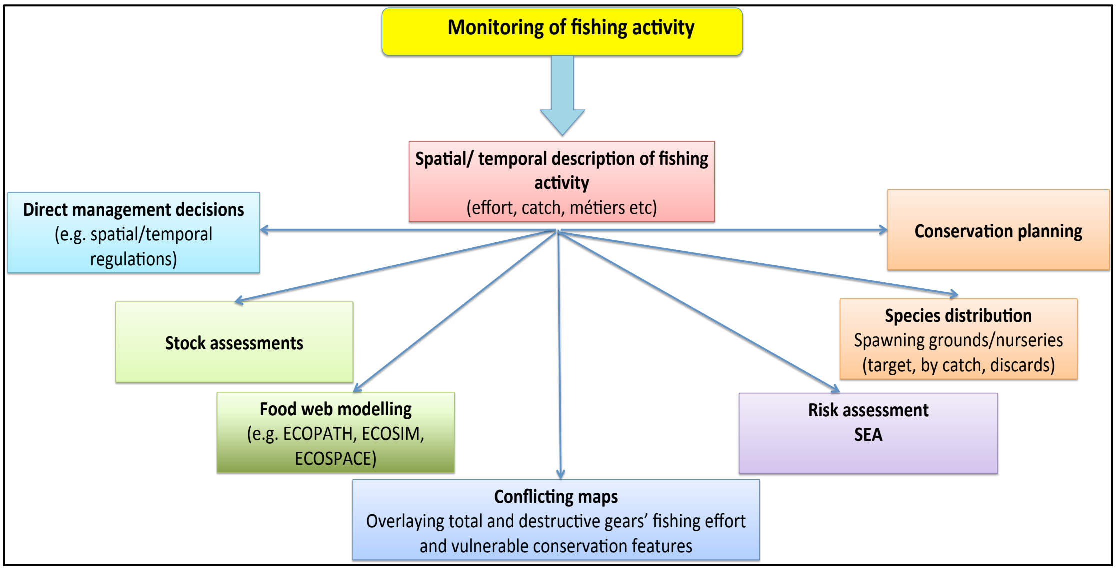

Figure 11 Capacity of monitoring information relevant to fishing activity with the suggested monitoring protocol. Depending on the aim, different approaches and analyses may be applied and provide further feedback to decision making.

The use of simple spatial indicators and analysis are suggested in order to describe fishing pressure and identify areas that receive the greatest fishing effort (Markantonatou et al., 2014). The generic framework suggested for long-term monitoring integrates powerful spatial analysis and visualization, which may provide a holistic assessment and scientific advice towards ecosystem-based fisheries management (see Appendix). The approach integrates information originating from a range of monitoring strategies that may be adopted depending on the capacity of MPA management system, and incorporates uncertainty regarding available information following the precautionary principle. Long term monitoring and geo-referenced information regarding species distribution and the health status of habitats may improve the quality of this analysis. However, the importance of local responsibility and surveillance in the area must be highlighted as an important component to achieve win-to-win outcomes (Markantonatou et al., 2015).

The guidelines correspond to a wide range of EU Directives, such as the Common Fishery Policy, the Marine Strategy Framework Directive and the Directive of Marine Spatial Planning, that promote the good environmental status of habitats and seafloor integrity, and sustainable exploitation of marine resources. We suggest monitoring of spatial pressure indicators, such as fishing effort, as the most basic useful and comprehensive tools that are easily communicated regarding fishing footprint on vulnerable habitats. They respond rapidly to ecosystem changes from human activities and management actions (Piet and Hintzen, 2012; Piet et al., 2007), can be monitored and measured precisely, and therefore may inform for effective decision making.

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References

Bo, M., Bava, S., Canese, S., Angiolillo, M., Cattaneo-Vietti, R., Bavestrello, G., 2014. Fishing impact on deep Mediterranean rocky habitats as revealed by ROV investigation. Biological Conservation 171, 167–176. doi:10.1016/j.biocon.2014.01.011

Cadiou, G., Boudouresque, C.F., Bonhomme, P., Le Direach, L., 2009. The management of artisanal fishing within the Marine Protected Area of the Port-Cros National Park (northwest Mediterranean Sea): a success story? ICES Journal of Marine Science 66, 41–49. doi:10.1093/icesjms/fsn188

Canella, L., 2012. Studio della pesca professionale nel comprensorio portofinese. Dipartimento di Scienze della Terra, dell'Ambiente e della Vita dell'Università di Genova. Genova.

Cappanera, V., Venturini, S., Campodonico, P., Blini, V., Ortenzi, C., 2012. Valutazione dell'impatto antropico sul sistema costiero, con particolare riferimento alla pressione antropica all'interno dell'Area Marina Protetta del Promontorio di Portofino. Portofino MPA.

Dillon, B., 2004. A bio-economic review of recreational angling for Bass (*Dicentrachus labrax*). Scarborough Centre for Coastal Studies.

Diviacco, G., Coppo, S., 2006. Atlante degli habitat marini della Liguria. Centro Stampa Offset, Genova.

Esparza Alaminos, O., 2010. Estudio de la pesca artisanal en el entorno de la reserva marine Cabo de Palos- Islas Hormigas. Estrategias de pesca, efecto de la proteccion y propuestas para la gestion. PhD Thesis. Facultad de biologia, Departamento de ecologia e hidrologia, Universita de Murcia.

EU, 2004. Mediterranean: guaranteeing sustainable fisheries. Fishing in Europe 21: 12

FAO, 2009. The State of World Fisheries and Aquaculture: 2008. FAO Food and Agriculture Organization of the United Nations, Rome, 2009, p.176

Font, T., Lloret, J., Piante, C., 2012. Recreational fishing within Marine Protected Areas in the Mediterranean. MedPAN North Project WWF France.

Freire, J., García-Allut, A., 2000. Socioeconomic and biological causes of management failures in European artisanal fisheries: the case of Galicia (NW Spain). Marine Policy 24, 375–384. doi:10.1016/s0308-597x(00)00013-0

Gaudin, C., De Young, C., 2007. Recreational fisheries in the Mediterranean countries: a review of existing legal frameworks. OECD Publishing. doi:10.1787/20743165

Giakoumi, S., Sini, M., Gerovasileiou, V., Mazor, T., Beher, J., Possingham, H.P., Abdulla, A., Çinar, M.E., Dendrinos, P., Gucu, A.C., Karamanlidis, A.A., Rodic, P., Panayotidis, P., Taskin, E., Jaklin, A., Voultsiadou, E., Webster, C., Zenetos, A., Katsanevakis, S., 2013. Ecoregion-Based Conservation Planning in the Mediterranean: Dealing with Large-Scale Heterogeneity. PLoS ONE 8, e76449. doi:10.1371/journal.pone.0076449

Gilman, E., 2015. Status of international monitoring and management of abandoned, lost and discarded fishing gear and ghost fishing. Marine Policy 60, 225–239. doi:10.1016/j.marpol.2015.06.016

Katsanevakis, S., Maravelias, C.D., Kell, L.T., 2010. Landings profiles and potential métiers

in Greek set longliners. ICES J. Mar. Sci. 67, 646–656. doi:10.1093/icesjms/fsp279
Leleu, K., Pelletier, D., Charbonnel, E., Letourneur, Y., Alban, F., Bachet, F., Boudouresque, C.F., 2014. Métiers, effort and catches of a Mediterranean small-scale coastal fishery: The case of the Côte Bleue Marine Park. Fisheries Research 154, 93–101. doi:10.1016/j.fishres.2014.02.006
Mariotti, M., 2012. Analisi del pescato professionale nel comprensorio portofinese: studio di un caso. Dipartimento di Scienze della Terra, dell'Ambiente e della Vita dell'Università di Genova. Genova.
Markantonatou, V., Meidinger, M., Sano, M., Oikonomou, E., di Carlo, G., Palma, M., Ponti, M., Cerrano, C., 2013. Stakeholder participation and the use of web technology for MPA management. Advances in Oceanography and Limnology 4, 260–276. doi:10.1080/19475721.2013.851117
Markantonatou, V., Marconi, M., Cappanera, V., Campodonico, P., Bavestrello, A., Cattaneo-Vietti, R., Papadopoulou, N., Smith, C., Cerrano, C., 2014. Spatial allocation of fishing activity on coralligenous habitats in Portofino MPA (Liguria, Italy), in: Bouafif, C., Langar, H., Ouerghi, A. (Eds.). Presented at the UNEP/MAP- RAC/SPA, Proceedings of the second Mediterranean Symposium on the conservation of Coralligenous and other Calcareous Bio-Concretions. Portorož, Slovenia, 29-30 October 2014, Portorož, Slovenia, pp. 118–123.
Markantonatou, V., Marconi, M., Cerrano, C., 2015. Guidelines for monitoring pressure and impacts from small scale and recreational fishing activity in Mediterranean Marine Protected Areas, ITM MMMPA project Deliverable D5.2.4, Ancona.
Markantonatou, V., Marconi, M., Cerrano, C., *in prep*. Susceptibility assessment of seafloor to lost fishing gear in data poor areas. In preparation.
Maynou, F., Morales-Nin, B., Cabanellas-Reboredo, M., Palmer, M., García, E., Grau, A.M., 2013. Small-scale fishery in the Balearic Islands (W Mediterranean): A socio-economic approach. Fisheries Research 139, 11–17. doi:10.1016/j.fishres.2012.11.006
Maynou, F., Recasens, L., Lombarte, A., 2011. Fishing tactics dynamics of a Mediterranean small-scale coastal fishery. Aquatic Living Resources 24, 149–159. doi:10.1051/alr/2011131
Mazor, T., Possingham, H.P., Edelist, D., Brokovich, E., Kark, S., 2014. The Crowded Sea: Incorporating Multiple Marine Activities in Conservation Plans Can Significantly Alter Spatial Priorities. PLoS ONE 9, e104489. doi:10.1371/journal.pone.0104489
Meidinger, M., Vasiliki, M., Sano, M., Palma, M., Ponti, M., 2013. Seafloor mapping and cartography for the management of marine protected areas. Advances in Oceanography and Limnology 4, 120. doi:10.4081/aiol.2013.5340
Piet, G.J., Hintzen, N.T., 2012. Indicators of fishing pressure and seafloor integrity. ICES J. Mar. Sci. 69, 1850–1858. doi:10.1093/icesjms/fss162
Piet, G.J., Quirijns, F.J., Robinson, L., Greenstreet, S.P.R., 2007. Potential pressure indicators for fishing, and their data requirements. ICES J. Mar. Sci. 64, 110–121. doi:10.1093/icesjms/fsl006
Prato, G., Barrier, C., Francour, P., Markantonatou, V., Cappanera, V., Guidetti, P., Cattaneo-Vietti, R., Mangialajo, L., Gascuel, D., in prep. A trophic modelling approach to assess artisanal and recreational fisheries impacts and conflicts in MPAs. *In preparation.*
Salmona, P., Verardi, D., 2001. The marine protected area of Portofino, Italy: a difficult balance. Ocean and Coastal Management 44, 39–60.
Stelzenmüller, V., Rogers, S.I., Mills, C.M., 2008. Spatio-temporal patterns of fishing pressure on UK marine landscapes, and their implications for spatial planning and management. ICES J. Mar. Sci. 65, 1081–1091. doi:10.1093/icesjms/fsn073
Tzanatos, E., Castro, J., Forcada, A., Matić-Skoko, S., Gaspar, M., Koutsikopoulos, C., 2013. A Métier-Sustainability-Index (MSI25) to evaluate fisheries components: assessment of cases from data-poor fisheries from southern Europe. ICES J. Mar. Sci. 70, 78–98. doi:10.1093/icesjms/fss161
Zapata-Ramirez, P., HueteStauffer, C., Scaradozzi, D., Marconi, M., Cerrano, C., 2015. Mapping and modelling the distribution of coralligenous and cave environments, a

multi approach to assess the Good Environmental Status (GES) at Portofino MPA. *Submitted.*

Chapter IV

Informing management decisions in Portofino MPA: A pressure-impact assessment of fisheries on coralligenous communities

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Abstract

Coralligenous are considered both vulnerable and essential fish habitats, yet little is known regarding their response to human pressures. Although trawling is considered the most important threat, recreational and artisanal fishing may also cause severe damage to their long-lived, key structural species. Characterizing fishing activity in the Mediterranean requires complicated approaches due to the increased heterogeneity and combination of gears, the variation of target species and the poor data availability. Monitoring and mapping of fishing pressure is just the first step to allocate fishing impacts on vulnerable habitats and seafloor integrity. More integrated approaches are necessary in order to understand the risks of fishing activity on conservation targets and efficiently inform management response.

The present study identifies the potential risk of coralligenous degradation or loss in Portofino MPA (Italy) by integrating fishing pressure and habitat vulnerability assessments through a standardized protocol. The approach considers the cumulative impacts caused by different fishing practices such as (i) direct mechanical damage; (ii) abrasion from lost gear; (iii) input of non-synthetic compounds of fuels from fishing boats; (iv) suffocation from sediment re-suspension.

In comparison to other attempts towards this direction the suggested method takes into account the heterogeneity of techniques and captures the different scale of impacts on benthic habitats in a systematic way, providing a useful tool that integrates ecological, management and policy interventions. The risk assessment can be easily applied and communicated in a straightforward way by managers, and has the potential to be expanded for assessing threats of fishing activity at different ecological components.

Keywords: Risk assessment; cumulative impacts; fishing pressure; vulnerability; ecosystem-based management; coralligenous

1. Introduction

Human activities exert pressure on complex environments and their cumulative environmental effects on the system varies according to their intensity, number and spatial and temporal scales (Smith et al., 2014). Hence, management decisions ideally should be guided by an understanding of how multiple threats from impact ecological components or specific ecosystem services in a given location (Giakoumi et al., 2015). The typical management process ideally includes the routine collection of information (‘monitoring’) from which the impacts on benthic habitats and species are being evaluated, leading to a management response and ultimately the mitigation of unacceptable impacts upon benthic habitats. To successfully describe the trade offs between the human activities and the environment while supporting the decision-making needs of environmental managers, an advanced and flexible problem-solving approach is necessary (Knights et al., 2015). Ecological assessments are a formal synthesis and quantitative analysis frameworks that integrate information on natural and socio-ecological factors in relation to specified ecosystem management objectives and lead to the identification of management actions to balance human impacts (Levin et al., 2009).

Any one sector-pressure-ecological component combination can be described as an impact chain that may be expressed by a weighting the vulnerability of a habitat to each impact (Robinson et al., 2013). Vulnerability is broadly defined as the likelihood of decline or extinction and time to extinction or to some threshold population level in the risk analysis and hazard assessment (Cutter 1996; Dilley and Boudreau 2001). It describes how human interactions influence particular biophysical attributes and the structure and functioning of marine ecosystems as a whole (Foley et al., 2013). The vulnerability assessment identifies the importance of cumulative impact analysis in evaluating environmental risks as the probability of an effect causing an impact at a system (Elliott, 2014). Cumulative impact assessment will describe the likelihood and consequences of an event (Knights et al., 2015) and inform management decisions in addressing human activities towards conservation targets (e.g. Breen et al., 2012; Hobday et al., 2011; Knights et al., 2015; Piet et al., 2015; Williams et al., 2011).

Habitats and species can be vulnerable to the accumulation of pressures at a certain cumulative impact level, which depends on the number and intensity of co-occurring activities (Foley et al., 2013). The analysis may focus on one or multiple sectors, or in a single habitat (Giakoumi et al., 2015). It is usually based on a conceptual model that identifies the pathways through which activities cause harm and describing the likelihood and consequences of an event (Fletcher et al., 2010; Leslie and McLeod, 2007; Smith et al., 2014). Vulnerability assessments quantify the causal-chain links between biophysical attributes and to human stressors that are described in the conceptual models and inform on risks of loosing potential conservation targets (Piet et al., 2015).

The present study focuses in understanding and assessing the impacts of fishing activity on seafloor integrity and vulnerable habitats such as coralligenous in Portofino Marine Protected Area (Liguria Sea, Italy), in order to improve management decisions regarding the protection of this precious habitat. This area is of particular importance due to the small surface of the MPA in relation to the high recreational and artisanal fishing activity that is operating on vulnerable benthic habitats present. The approach is based on the cumulative impacts caused by different fishing practices operating in an MPA, but presents a transparent and repeatable in terms of methods, data and assumptions used in the analyses regarding the interaction of coralligenous with the various fishing techniques. The developed methodology offers guidance on how to structure and focus efforts for collecting, synthesizing and analyzing of necessary information to inform holistically policymaking and management processes. In comparison to other attempts (e.g. Breen et al., 2012; Cabral et al., 2014; Hobday et al., 2011; 2007; Knights et al., 2015; Purroy et al., 2014; Samhouri and Levin, 2012; Smith et al., 2007; Weaver et al., 2011; Williams et al., 2011), the suggested method takes into account the heterogeneity of techniques and captures the different scale of impacts on benthic habitats in a systematic way, providing a useful tool that integrates ecological, management and policy interventions. This is one of the few studies (Grieve et al., 2014; Purroy et al., 2014) that recreational and artisanal fishing impacts have been assessed in a systematic and holistic approach.

2. Impacts of fishing activity on coralligenous communities

Coralligenous habitats are calcareous algae stems forming unique deep subtidal bio-constructions growing in dim light in the mesophotic zone, relatively calm waters on rocky bottoms of depth 12-120m (Ballesteros, 2006). They are characterized by a wide heterogeneity, structural complexity, and high biodiversity formed by long-lived key species with slow population dynamics, such as sponges, gorgonians and the red coral (Ballesteros, 2006; Garrabou and Harmelin, 2002; Gili and Coma, 1998). Due to the very slow growth rate of coralligenous habitats, physically and functionally fragile, are easily disturbed and very slow to recover (FAO, 2009). Their recovery depending on the environmental conditions and the cumulative human activities operating on the habitat, may take decades, or may never recover (Cerrano et al., 2010; 2005). For instance, maërl extraction has major effects on the wide range of species present in both live and dead maërl deposits, hence it is considered to be is considered to be a non- renewable resource (Barbera et al., 2003).

Coralligenous are widely recognised for their importance to fisheries in the Mediterranean serving as important spawning, feeding and reproduction grounds for several endemic, commercial and endangered species (Cocito, 2004; Laborel, 1987; Piazzi et al., 2012; Salomidi et al., 2012). Several sessile invertebrates inhabiting coralligenous are included in the Barcelona and the Bern conventions. Coralligenous communities have been included in the Annex I of the Habitats Directive and the Article 4 of the European Regulation CE 1967/2006 as essential fish habitat vulnerable to destructive fishing methods such as trawling and purse seine. Finally, the Action Plan established by RAC/SPA in 2008 recommends that Marine Protected Areas (MPAs) with coralligenous present in their area should develop management and monitoring plans in order to ensure their protection and good health status.

However there is a limited understanding and knowledge on coralligenous in comparison to other vulnerable coastal habitats such as *Posidonia oceanica* meadows. For years lack of distribution maps and sufficient data could not support the protection of these vulnerable habitats and the establishment of protected areas due to their presence.

Despite the significance of coralligenous a range of human activities still degrades these vulnerable habitats (Sala et al., 2012). Fishing is considered one of the main threats of coralligenous that may cause severe damage to long-lived, key structural species, altering the habitats' complexity and seafloor integrity (Ballesteros, 2006; Piazzi et al., 2012). Although trawling is considered by far the most destructive method (Kaiser et al., 1996; 1998), more and more frequently though new studies show that small scale and recreational fishing practices may have an impact on coralligenous health status (Ballesteros, 2006; UNEP, 2007).

Coralligenous are extremely prone to mechanical disturbance (Bourcier, 1986; Cinelli et al., 2007; Hong, 1982) through breaking or abrasion of sessile, long-lived organisms, with slow growth dynamics and limited recovery capacity (Ballesteros et al., 2006; Salomidi et al., 2012). This impact takes place as the gears come in contact with the sea-bottom, or drag and roll along digging into the seafloor (Kružić, 2014). The fishing gear characteristics and fishing strategies employed have a key role in determining the impact of fishing on the seabed and associated benthic communities (Sink et al., 2012). Moreover, the increasing fishing effort, and technology and changes in fishing strategy, as well as through increased fishing efficiency and effort, and the advances in fishing gear that became more resistant and larger, has progressively drove the increasing spatial extent of the fishery to include greater depth and more rugged terrain (Sink et al., 2012). Puig et al. (2012) demonstrated that trawling-induced sediment displacement and removal from fishing grounds causes the morphology of the deep sea floor to become smoother over time, reducing its original complexity as shown by high-resolution seafloor relief maps (Fig. 1). The effects of low habitat complexity particularly in hard substrate and biogenic reef communities due to the presence of trawling or dredging (e.g. Collie et al., 2000), and decreased productivity linked to low benthic biomass have also been reported (Jennings et al., 2001). The consequent decline of complexity results from the reduction in the abundance and/or size of large gorgonian and other erect species, such as *Axinella spp*. and *Hornera frondiculata* (Tunesi et al., 1991). The reduction of complexity could infer further biodiversity loss, however the extent of this impact and the associated mechanisms are still poorly understood (Cerrano et al., 2010).

Direct mechanical damage may also be caused through anchoring of the fishing boat or the gear itself. Coralligenous concretions of frequently visited sites by recreational fishing or diving activities are degraded by the destructive potential of anchors (UNEP-MAP, RAC/SPA, 2015). Anchoring has a severe impact on coralligenous concretions as most of the engineering organisms are very fragile and may be easily detached or broken by anchors and chains (Ballesteros, 2006). Lost fishing gear is well known for the introduction of synthetic compounds such as nylon in the marine environment and the mechanical damage that causes to gorgonians through abrasion (loss of living tissue) (Angiolillo et al., 2015; Bo et al., 2014; Linares et al., 2007; Piazzi et al., 2012). (Bavestrello et al., 1997) concluded that the major cause of mortalities in the gorgonian *Paramuricea clavata* in Portofino MPA was the destruction of tissue from fishing lines, which caused the colonization of epibionts on the denuded skeleton and resulted in weakness of the skeleton and mechanical stress due to resistance to the water movement.

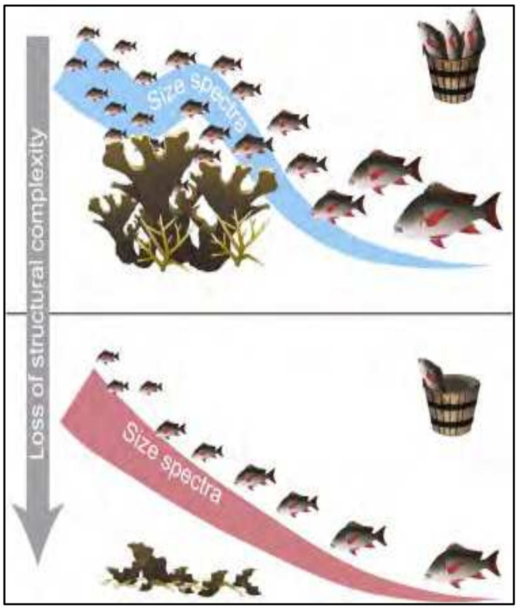


Fig. 1: Loss of functional diversity due to intensive fishing. Adopted by Kennedy et al. (2013)

Coralligenous assemblages are sensitive to environmental changes even at a small scale (Garrabou and Ballesteros, 2000; Sartoretto and Francour, 1997). Increased water turbidity, sedimentation and re-suspension of lighter sediment fraction caused by mobile gears can affect nutrient cycling, oxygenation and sediment redistribution and result to indirect degradation of coralligenous communities (Balata et al., 2005; Cinelli et al., 2007; Salomidi et al., 2012; Widdicombe et al., 2004). For instance, trawling close to coralligenous outcrops or maërl beds affects negatively algal growth and suspension-feeding due to increased turbidity and sedimentation (Kružić, 2014). Heavy re-suspension of soft sediment habitats can also affect adjacent more sensitive deep water corals (Grieve et al., 2014).

Finally, the use of boats during fishing, introduces non-synthetic compounds such as fuel and oil into the marine environment that may burden coralligenous health status (Lloret et al., 2008). Pollution is the most widespread source of anthropogenic impact on marine ecosystems and depending on the features of pollutants it may cause a different magnitude of impact (e.g. composition, toxicity, persistence). Pollution from oil tend to persist on the surface for a long time in which they can be distributed by water movements, but may also cause the death of the biota by impeding respiratory exchanges of organisms. Gorgonian octocorals and antipatharians are susceptible to exposure to waterborne toxicants through their polyps (Sherwood et al., 2005; Sulak et al., 2008), while the most likely mechanism for oil/dispersant exposure is the passive or active sinking of contaminated surface material toward the benthos and/or re-suspension and advection of contaminated surface material in sediments (Passow et al., 2012). Transport of surface particulates to deep-water corals can be rapid (Davies et al., 2009) and although oil contaminants would be unlikely to accumulate in large quantities on the sediment surface, as suspended material could cause harm to suspension feeders such as corals, coming into contact with them (Etnoyer et al., 2015). The few studies conducted in octocorals exposed to contaminants have reported deleterious effects including polyp mortality and discoloration (DeLeo et al., 2015; Silva et al., 2015), inhibition of metamorphosis (Kushmaro et al., 1997), and behavioral changes (Cohen et al., 1977). Patchy distribution of injuries in the Paramuricea gorgonian have been linked to oil contaminated sediments recovered from the branches and polyps of gorgonians (Desvousges et al., 2012; Fisher et al., 2014).

3. Methods

3.1 Spatial distribution of fishing footprint on benthic habitats

Fishing effort (hours * year-^{1} * m-^{2}) from 24 artisanal fishermen (in 2014) and 247 recreational fishermen (in 2012) currently active in the Portofino MPA was monitored and mapped in ArcGIS 10.2 using a 1 by 1 m^2 cell size, as described in (Markantonatou et al., 2014; *in prep*.). We have considered the different fishing practices as the drivers, or 'the mechanisms through which an activity has an effect on any part of the ecosystem' (Robinson et al., 2013). Spatial analysis was used to describe the pressures that benthic habitats are subject to due to artisanal and recreational fishing activity in Portofino MPA. More specifically the components measured:

- The spatial extend of driver *i*: defined as the total surface area covered by the driver under study (Sink et al., 2012), this information assists in allocating the spatial distribution of fishing activity and identify the areas that receive the most fishing pressure in terms of annual fishing effort.

- The spatial extend of habitat *j*: defined as the total amount of the habitat types present in the study area (Kryvenko et al., 2014). It has also been called '*areal extent*' by (Williams et al., 2011). It assists in understanding the amount of habitat type under risk in terms of the habitat rarity in relation to the proportion of the habitat that is exposed to the pressure (Sink et al., 2012).

- The spatial overlap (exposure) of driver *i* on habitat *j*: defined as the spatial extent of overlap between the pressure's extend and an ecological characteristic, it identifies the areas that are subject to the different levels of fishing pressure (Breen et al., 2012; Giakoumi et al., 2015; Halpern et al., 2007; Hobday et al., 2007; Robinson et al., 2013). Vulnerable habitats receiving the highest fishing pressure were identified as those areas that receive 90% of the total activity occurring for a specific bottom fishing fleet, in accordance with the suggestion of the Data Collection Framework (DCF) of the Common Fisheries Policy (EC, 2008; EC, 2008)(EC, 2008a;b) for long-term surveying and the provision of scientific advices towards ecosystem-based fisheries management.

Habitat threat status, current habitat protection levels and trends of fishing effort over the past years, were also considered for all habitat types that occur within the fishing footprint, to further support the identification of priorities, legal or management gaps and potential management measures (Sink et al., 2012).

3.2 Vulnerability assessment

In the previous section we identified areas that are subject to high fishing effort. However, when assessing impacts, what needs to be take into consideration is (i) the driver in terms of spatial scale, the frequency and intensity of fishing activity, including the history of the activity (Collie et al., 2000; Kaiser, 1998; et al., 2003; 2000; Kaiser and Spencer, 1996); (ii) the habitat type including habitat complexity and all those factors affect the inherent vulnerability of the different habitat types and their species (FAO, 2009; Heifetz et al., 2009; Miller et al., 2009; Reed, 2002; Reed et al., 2007; Stone, 2006; Wheeler et al., 2005); (iii) the type of fishing operation including gear characteristics and fishing strategies employed (Sink et al., 2012; Thrush and Dayton, 2002).

The vulnerability assessment incorporates the interaction of habitat (coralligenous) and fishing pressure based on a conceptual framework, in which linkages between pressure mechanisms and potential impacts on ecological components of the ecosystem are described. In this step the key threats to ecological components and policy objectives are being weighted and rationalized (Robinson et al., 2013; Piet et al., 2015). To assess each components' vulnerability to human threats, we used five vulnerability measures including confidence (Fig. 2), based on those developed by Halpern et al. (2007) for ecosystems and Giakoumi et al. (2015) for the *Posidonia oceanica* meadows (Table 1 in Appendix).

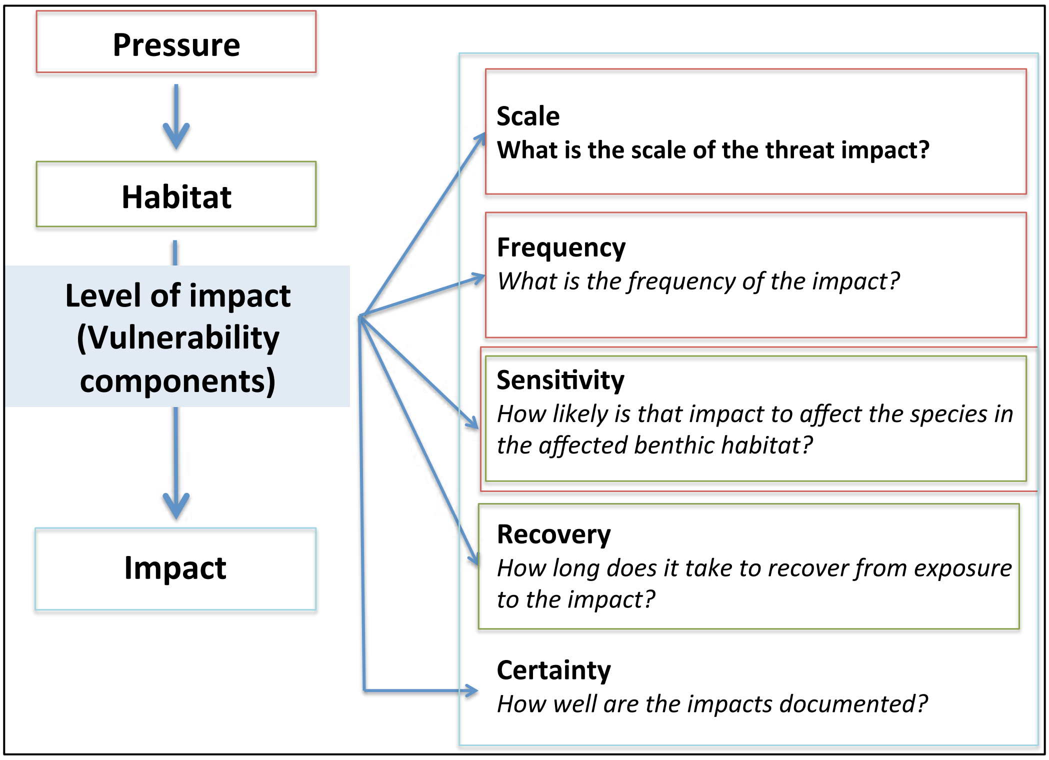


Figure 2: The vulnerability measures to assess human threats on benthic habitats

Each criterion was evaluated regarding the level of every impact identified. The impact was characterized in terms of impacts on coralligenous in four major categories: (i) pollution from possible boat use during fishing in terms of 'Introduction of non synthetic compounds in the marine environment' (MSFD, indicator 8) such as oil; (ii) direct mechanical damage, including breaking and abrasion from the gear and possible use of anchors; (iii) indirect damage from lost fishing gear; and (iv) sediment re-suspension causing suffocation of coralligenous communities. Normally the vulnerability criteria incorporate expert judgement that evaluates each vulnerability component of each ecosystem or habitat, to each driver. We have used a conceptual model (Fig. 1, Appendix) to identify the trade-offs between the different fishing practices and how each one can cause an impact to the ecological components of the habitat (Knights et al., 2013; Robinson et al., 2011).

To apply numerical scores to each qualitative assessment category we have combined a set of quantifiable assessment criteria describing how destructive each fishing technique is, or its potential to degrade on every feature present on the sea bottom. Information on the criteria was collated from the literature and defined the characteristics of the practice and the gear used that are related to each impact (Tables 2 and 3, Appendix). The criteria were later on prioritized and selected based on their capacity to be used as surrogates of the different potential impacts and the available information from monitoring. Like this we were able to discriminate the level of impacts from the different fishing practices on coralligenous and minimize the bias from expert judgement as much as possible. We have integrated several sources of information, such as the information retrieved from interviews, information from the EU Fleet Database[1], literature and direct observation. Moreover, through this process, information gaps for similar impact and risk analysis were highlighted. We have also integrated spatial rules based on the MPA management plan (zones B and C), local and national regulations regarding the number of hooks and gear allowed, length of gear and modifications of fishing practices, spatial closures etc., to better determine the variability of the fishing pressure within the study area.

Particular effort was made to assign scores for sensitivity, which in terms of habitat integrity, can be defined as how likely is that impact to affect the species in the area/habitat/population (Giakoumi et al., 2015). To assess sensitivity the above surrogates of gear destructiveness were combined with habitats' integrity features, namely (i) habitat rarity (extend of habitat in the MPA; Sink et al., 2012); (ii) functional significance of habitat; (iii) structural complexity (or ruggedness); and (iv) fragility (FAO, 2009). Resilience for a predominant habitat is defined as the recovery time of the characteristic species of the habitat ('ecological characteristics') to return to pre-impact, or prevailing conditions (Knights et al., 2015). The recovery of a habitat or a community depends from the life-history traits of component species,

[1] ec.europa.eu/fisheries/fleet/

hence normally is assessed at the species level by using the list of characteristic species for each habitat. Very frequently regeneration rates of keystone species are considered a good surrogate of the habitat recovery (Knights et al., 2015; Williams et al., 2011).

Due to the limited information about most of the species distribution and their health status, the habitat sensitivity and recovery were considered in the context of the the most vulnerable key habitat species selected, as suggested by Hobday et al. (2007; 2011). Therefore 7 characteristic species for coralligenous habitats (*Paramuricea clavata; Eunicella cavolini; Eunicella singularis; Eunicella verrucosa; Axinella sp.; Corallium rubrum; Myriapora turnicata*) that function as engineers for the habitat were selected, for which we are certain regarding their presence in the area and life cycle exists. Regeneration rate was considered a priority indicator for assessing recovery scores. When this information did not exist, other life history traits were considered for the assessment, such as reproduction rate; growth rate; life span (Sink et al., 2012; Williams et al., 2011). Information was collected through for every species and the life cycle features selected.

We resized “scale” and “sensitivity” values to range from 0 to 4, so that all vulnerability measures are in the same scale (Giakoumi et al., 2015). Initially, the vulnerability weights were calculated for each identified impact separately. We applied the aggregation method of the individual vulnerability components’ scores and averaged the final scores that represented the specific impact from a fishing practice causes on coralligenous within a given cell when both exist in that cell.

3.3 Cumulative Impacts assessment of fishing activity on coralligenous habitats

Initially, each individual impact caused by different fishing practices was evaluated separately, in order to provide useful information regarding the level of each impact chain that each pressure has on coralligenous. The following formula, adopted by Halpern et al. (2007), was applied using spatial analysis tools:

$$\text{Total individual impact} = \text{Driver}_i * \text{Weight}_{ij} * \text{Habitat}_j$$

Where i= fishing practice, j= habitats (in this case coralligenous)

Driver$_i$, is the footprint of a *fishing practice i* on a habitat *j*; here it is expressed as fishing effort in total hours per year per m^2 (intensity of exposure) and was normalized between 0-1, in order to have a unitless scale that allows direct comparison (Halpern et al., 2007). Effort is approximated by the spatial and temporal scale of the activity, which is an important consideration in evaluating the risk for impact for particular activities as suggested by Hobday et al. (2011).

$Weight_{ij}$ = a multiplication factor that expresses the level of impact for each practice (Halpern et al., 2007). It represents the vulnerability score that was assessed above (Section 3.2).

$Habitat_j$ = the overlap of a habitat *i* with the specific fishing practice *j,* expressed in absence (0) or presence (1); in this case the habitat *i* is the coralligenous habitats

For each 1 m^2 cell of marine part we multiplied each fishing pressure (effort of each fishing gear) layer with each ecosystem layer to create driver-by-ecosystem combinations, and then multiplied these combinations by the appropriate weighting variable ('vulnerability score').

To assess the cumulative impacts caused by fishing activity on coralligenous per 1 m^2 cell, the cumulative impact assessment formula was applied (Halpern et al., 2007), which suggests the aggregation of each fishing practice-by-coralligenous:

$$\text{Total Risk of impact} = \sum_{i=1}^{n}\sum_{j=1}^{m}(\text{Driver}_i * \text{Weight}_{ij} * \text{Habitat}_j)$$

4. Results

4.1 Spatial distribution of fishing footprint on benthic habitats

4.1.1. Spatial extend of artisanal and recreational fishing

The footprint of recreational and artisanal fishing covers in total the whole extend of the Portofino MPA. The fishing practices with the widest distribution in all the study area (Table 1) are the trammel and combined nets (total footprint surface area 6.32 km^2), recreational pelagic and bottom trolling (total footprint surface area 5.88 km^2 and 5.61 km^2 respectively), big fishing with rods equipped with reels (total footprint surface area 5 5.61 km^2), vertical jigging (total footprint surface area 5.31 km^2) and gill nets (total footprint surface area 5.17 km^2). The same gears dominate in spatial extend also inside the Portofino MPA, however gillnets have a greater extend within the MPA in comparison to bottom trolling and big game with rods, indicating a preference of artisanal fishers towards the MPA and the shallower parts.

Table 1. Total surface area (m^2) in and out of the MPA (study area) that are subject to the different fishing practices. Bold indicate highest values in each field.

Fishing Technique	Common depth (m)*	Effort range per m2 (hr/year-1)	Total surface area impacted (m2)	Total surface area impacted in MPA (m2)	Total surface area mostly impacted in MPA (m2)	% surface area mostly impacted in MPA (m2)
Bottom trolling †	15-150	0 - 433.583	**5612729.13**	**2765755.47**	170575.16	6.17
Pelagic trolling †	>10	0 - 665.875	**5883558.4**	**2989527.4**	227954.61	**7.63**
Fishing Cephalopods on boat †	5-80	0 - 925.458	4738502.87	2495989.31	197540.3	7.91
Longlines †	15-300#	0 - 631.16	513555.67	2319815.07	97453	4.20
Vertical jigging †	20-150	0 - 289.25	**5305632.94**	**2517926.92**	2112234.8	**83.89**
Big game with rod †	10-300 (with rod)	0 - 221.33	**5611323.39**	**2765747.17**	**586026.63**	**21.19**
Big game with hand †	15-50	0 - 3217.58	2944395	1561256.01	**404008**	**25.88**
Bottom fishing †	0-30/50**	0-582.47	684189.4	579336.11	**14216.5**	2.45
Rockfishing †	20-100**	0 - 4440	964353	831346.88	139649.25	16.80
Beach ledgering †	0-50**	0-60	130201	91687.88	91687.88	**100.00**
Surfacasting †	20-100**	0 - 1010	840601.67	731791.98	**232746.64**	**31.81**
Fishing Cephalopods from coast †	0-40	0 - 244	433494	394180.25	79666	**20.21**
Drifting †	0-50	0 - 24	1031219.77	881011.25	145032.63	16.46
Natelli (drifting) †	20-80	0 - 41.66	4085025.36	2260509.05	222766	9.85
Galleggiante †	0-30**	0-345	376716	324746.82	14225	4.38
Spinning †	0-50**	0-2182.88	718900	603548.85	14225	2.36
Trammel/ Combined nets §	>3	0 - 25572	**6323767.75**	**3382118.16**	102193.35	3.02
Gill nets §	>5	0 - 7112	**5174448.05**	**2844700.61**	79982.17	2.81
Bottom longlines §	>5#	0-760	4575913	2372950.9	76329.94	3.22
Artisanal total	>3	0 - 32944	6323811	3381822.47	204654.75	6.05
Recreational total	>0	0 - 10682	6416452	3409326.66	19238	0.56

(*) highly depends from local sea bottom morphology; *(**) distance from coast is provided as more accurate measure of mapping, regarding fishing from coast*; *(#) activity spatially regulated in MPA; (§) artisanal fishing practice; (†) recreational fishing practice*

When considering however the amount of effort received in the MPA we get a different picture. The gears with the highest effort ($hrs*year^{-1}*m^{-2}$) per cell in the whole study area are shown in Table 1. Artisanal nets having the highest effort from all practices (max effort 25572 $hrs*year^{-1}*m^{-2}$ for trammel and combined nets, and 7112 $hrs*year^{-1}*m^{-2}$ for gillnets), as expected due to the persistency of the practices throughout the year and the high amount of hours that the gears remain in the sea active (ranging from 5-12 hours depending on the technique and the target species). The fishing practices that note their maximum effort (90% of their total effort) inside the MPA are vertical jigging with maximum footprint which occupies in MPA 2.11 km^2 (about 84% of the total MPA area), big game (max. footprint in MPA more than 0.6 km^2 which occupies about more than 22% of the total MPA area), surfcasting and pelagic trolling (max. footprint in MPA 0.23 km^2 which occupy about 31.8% and 7.6% of the total MPA area respectively).

4.1.2. Spatial extend of habitats

The dominant habitat in the study area (Table 2) is the muddy detritus (about 2.9 km^2) and detritus (0.95 km^2).

DESCRIPTION	Total surface (m2)	Surface in Zone A (m2)	Surface in Zone B (m2)	Surface in Zone C (m2)	Total surface in MPA (m2)	Total surface outside MPA (m2)
Algae sciaphilous circalittoral	3230.936404			2645.59688	2645.597	585.339525
Coarse sediment (sand, gravel and pebbles)	38936.74862	6408.750093	25988.32304		32397.07	6539.67548
Coastal mud	856081.8161		10214.0883	300623.9431	310838	545243.785
Coralligenous	206818.419	7211.546147	157388.0723	16030.89001	180630.5	26187.9105
Dead matte of Posidonia	230042.0695		3196.528822	157821.2251	161017.8	69024.3156
Detrital coastal populations	952375.3471	30566.76	406792.1263	131198.6802	568557.6	383817.781
Mosaic formations of *Posidonia* alive and dead	126284.9018		379.4427735	101316.3147	101695.8	24589.1443
Photophilous infralittoral algae on hard substrate	303862.3827	15386.97033	96008.24663	153489.7727	264885	38977.3931
Populations of muddy detritus	2894585.713	74969.71574	777239.774	316800.7284	1169010	1725575.5
ports	27467.99644					
Posidonia and rocks	154371.3655	8306.359769	15451.85292	110768.3849	134526.6	19844.7679
Posidonia oceanica (primarily matte)	420177.9951	5294.483724	1173.045123	357555.5181	364023	56154.9482
Sandy bottom (broadly)	261686.1411	3530.804475	1424.600487	173840.2021	178795.6	82890.534
Sciaphilous infralittoral algae	167270.9917	10980.1906	131718.0875	19816.4394	162514.7	4756.27421
Semi-dark caves and dark	5151.396511	386.5223251	4664.113896	100.76029	5151.397	0

Table 2: Surface area of habitats present in the study area (Total surface (m^2)); surface area of habitats in zones A, B and C (m^2); surface area of habitats in and put of the MPA within the borders of the study area (m^2). Information extracted from Diviacco and Coppo, 2006, updated in 2012.

Inside the Portofino MPA, the most widespread habitat is the muddy detritus that covers a quite big area in comparison to other habitats (about 1.17 km^2) and detritus (0.57 km^2), followed by *Posidonia oceanica* matte (0.364 km^2) and coastal mud (0.31 km^2). Zone A is mainly characterized by populations of muddy detritus (0.075 km^2), detrital coastal populations (0.03 km^2), photophilous infralittoral algae on hard substrate (0.01 km^2) and sciaphilous infralittoral algae (0.01 km^2) while Posidonia mixed with rocks and coralligenous occupy a much smaller percentage (0.008 km^2 and 0.007 km^2 respectively). In zone B, apart from the detritus, coralligenous and schiaphilous algae (pre-coralligenous) cover 0.16 km2 and 0.14 km^2 respectively. On the contrary, zone C is mainly characterised by the presence of Posidonia oceanica (0.36 km^2), muddy detritus and mud (about 0.6 km^2 in total), sandy bottoms (0.17 km^2), while some dead Posidonia meadows are present within (0.16 km^2).

Coralligenous habitats in the study area (Fig.3) cover a surface of 0.21 km^2, of which 0.18 km^2 are located inside the MPA.

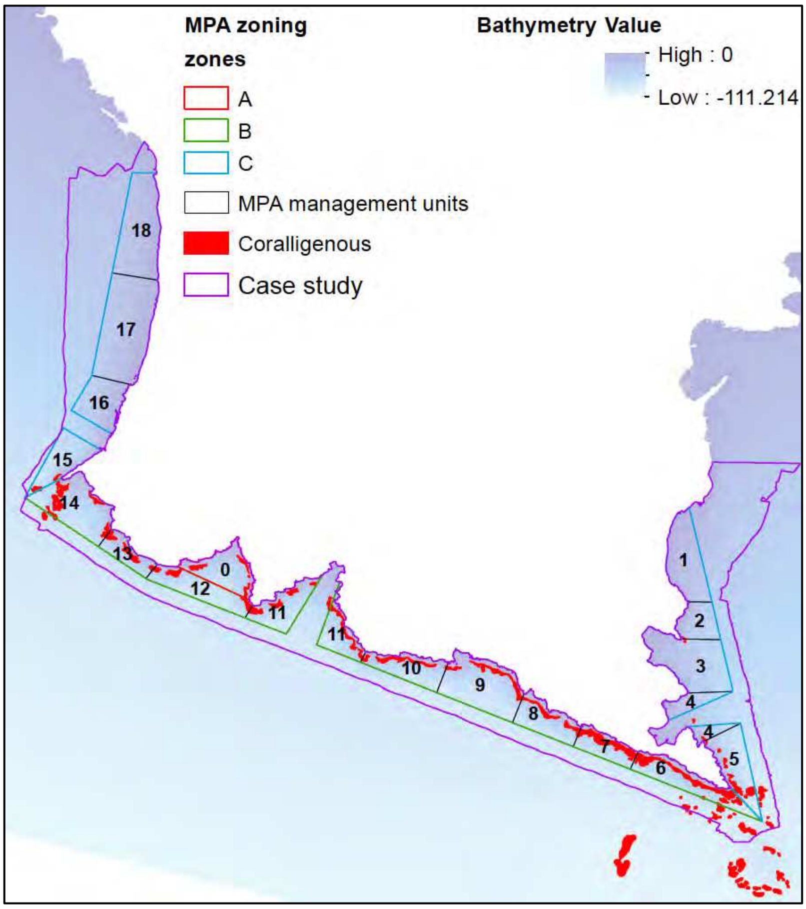


Figure 3: Distribution of coralligenous habitats in the wider area of Portofino Promontory.

Within the MPA, the management units with higher surface areas of coralligenous are 6 (19.63%), 7 (14.35%), 11 (11.71%) and 14 (10.98%). However, in the wider area of Portofino promontory coralligenous cover about 1.585 km^2, and the remaining 1.4 km^2 falls outside the MPA limits and is currently unprotected.

4.1.3. Spatial overlap of driver i on habitat j

All the coastal benthic habitat types of the case study are subject to fishing and fall within the fishing footprint. The fishing footprint is wider on the soft bottom communities in terms of surface area, in comparison to hard substrate communities. It is evident from Table 3 that, in terms of fishing effort, the majority of habitats receive a low to moderate fishing footprint, of about 25-75% of the total fishing activity.

DESCRIPTION	Zone A	0-10%	10-25%	25-50%	50-75%	75-90%	90-100%
Algal photophilous infralittoral of hard substrate	21.2	36.6	41.4	0.4	0.4	0.0	0.0
Algae sciaphilous circalittoral	0.0	0.0	17.7	10.1	72.2	0.0	0.0
Algae sciaphilous infralittoral	6.7	5.2	30.4	12.3	40.9	3.8	0.8
Coralligenous	3.9	0.1	1.5	4.8	48.7	38.9	2.1
Detrital coastal populations of muds	5.0	0.3	1.0	23.3	36.0	33.0	1.5
Populations of muddy debris	5.7	5.7	21.8	32.7	33.2	0.9	0.0
Coastal mud	0.0	5.6	4.8	50.8	38.9	0.0	0.0
Semi-dark caves and dark	7.6	4.9	6.9	4.0	30.2	40.8	5.6
Matte of dead Posidonia	27.6	0.7	16.9	54.4	0.3	0.1	0.0
Mosaic formations of Posidonia alive and dead	0.0	0.0	5.7	88.7	5.5	0.0	0.0
Posidonia oceanica (primarily on matte)	1.6	10.0	31.0	55.4	1.9	0.0	0.0
Posidonia and rocks	5.7	56.7	26.0	0.9	1.4	6.1	3.2
Sandy coasts (broadly)	2.9	26.4	35.6	27.9	7.0	0.1	0.1
Coarse sediment (sand, gravel and pebbles)	17.4	2.6	12.1	0.0	18.2	49.8	0.0

Table 3: % of total surface area of habitats being subject to different levels of fishing pressure (% of total effort) in the Portofino MPA.

More than 50% of *Posidonia oceanica* meadows present in the MPA are subject to moderate fishing effort (25-50%), within which dead matte of *P. oceanica* is present mainly located in the east part of zone C. A relevantly high surface of coralligenous and underwater caves, detritus and coarse sediment communities receive much higher fishing effort within the MPA.

Table 4 indicates the total surface area of coralligenous communities when we overlap the fishing footprint on the specific habitat. Coralligenous is subject to greater fishing effort from artisanal fishing, rather than the recreational. This could be probably due to the fact that artisanal fishing is a traditional activity in the area, hence small-scale fishermen are well aware of the seafloor morphology and key habitats present in the wider area of the Portofino Promontory.

Table 4: Pressure assessment of recreational and artisanal fishing practices on coralligenous. Techniques, range of effort (total hrs*yr^{-1}*m^{2}) in MPA and threshold account for 90% of the total activity for identifying most impacted areas, most impacted MPA management units and depth range (m), total area (m^{2}) most impacted by a tool, total area (m^{2}) of coralligenous mostly impacted by a tool, % most impacted coralligenous area of the total coralligenous in the MPA. In bold are the values of high concern for coralligenous habitats regarding the above criteria. (§) Artisanal technique; (†) recreational technique

Fishing Technique	Effort range in MPA (hr/year-1 * m-2)	90% effort threshold 90% (hr/year-1 * m-2)	Management units mostly impacted (depth range, m)	Total surface area mostly impacted (m2)	Surface area of coralligenous mostly impacted (m2)	% of total coralligenous mostly impacted IN MPA
Bottom trolling †	0 - 403.58	363.22	6 (20-60)	170575.16	34601.44	18.893
Pelagic trolling †	0 - 665.875	599.28	6-7 (20-50) 14 (20-55)	227954.61	70235.2	**38.350**
Fishing Cephalopods on boat †	0 - 863.45	777.105	3 (20-30) 5 (70-73)	197540.3	263.04	0.144
Longlines †	0 - 152	136.8	6 (50-80)	97453	7211.48545	3.938
Vertical jigging †	0-289.25	260.325	4-5 (5-20) 10 (20-50) 12 (20-50) 14 (15-20) 15 (20-50; 60-70)	2112234.81	147517.52	**80.547**
Big game with rod †	0-221.33	199.197	5-6; 9 (10-80)	586026.63	59973.07	**32.746**
Big game with handline †	0-2313.33	2081.997	4-5 (10-50)	353769.02	6506.43	3.553
Bottom fishing †	0-582.47	524.223	15 (10-20)	14216.5	36.4332	0.020
Rockfishing †	0- 4440	58.9815	4 (5-20) 6 (20-60) 7-9 (20-55) 13-15 (20-50)	139649.25	20266.53	11.066
Beach ledgering †	0-60	54	3;4 (5-20)	91687.88	723.05	0.395
Surfacasting †	0-1010	909	2-3 (20-30)	232746.64	331.41	0.181
Fishing Cephalopods from coast †	0-244	219.6	2-3 (10-25)	79666	386.7	0.211
Drifting †	0-24	21.6	5-6 (20-55)	145032.63	33632.63	18.364
Natelli (drifting) †	0-41.66	37.494	14 (20-60)	222766	21440.38	11.707
Galleggiante †	0-345	310.5	15 (10-20)	14225	36.01	0.020
Spinning †	0-2182.88	1964.592	15 (10-20)	14225	36.01	0.020
Trammel/ Combined nets §	0-10188	9169.2	6-11 (20-50)	102193.35	39661.1	**21.656**
Gill nets §	0-6312	5680.8	11 (40-55)	79982.17	4415.7	2.411
Bottom longlines §	0-760	684	6-11 (40-50)	76329.94	7372.45	4.025
Artisanal total	0-14645	13180.5	6-11 (30-50)	204654.75	51548.96	28.147
Recreational total	0 - 10682	9613.8	14 (15-50)	19238	3780.19	2.064

Although trammel nets and combined nets, as shown before, appear to have the greatest fishing effort, when overlapping fishing effort with coralligenous different practices appear to threat coralligenous habitats in terms of surface area. For instance vertical jigging, although has relevantly low effort, covers more than 80% of the coralligenous present inside the MPA at the shallow and deeper parts of the habitat (>40- 50m depth). Pelagic trolling and big game footprint cover over 30% of coralligenous, while on the contrary the coralligenous receiving the most fishing pressure from trammel and combined nets covers 21% of the total habitat coverage within the Portofino MPA.

The coralligenous located in the southern part of the promontory receives the majority of fishing effort. Most of the impacted coralligenous habitats overlapping with the 90% of the total fishing footprint within the MPA were located in the management units 6-11 at 30-40 m depth, with surface area exceeding 0.07 km^2 (38.9%) of the total coralligenous in Portofino MPA (fig. 4).

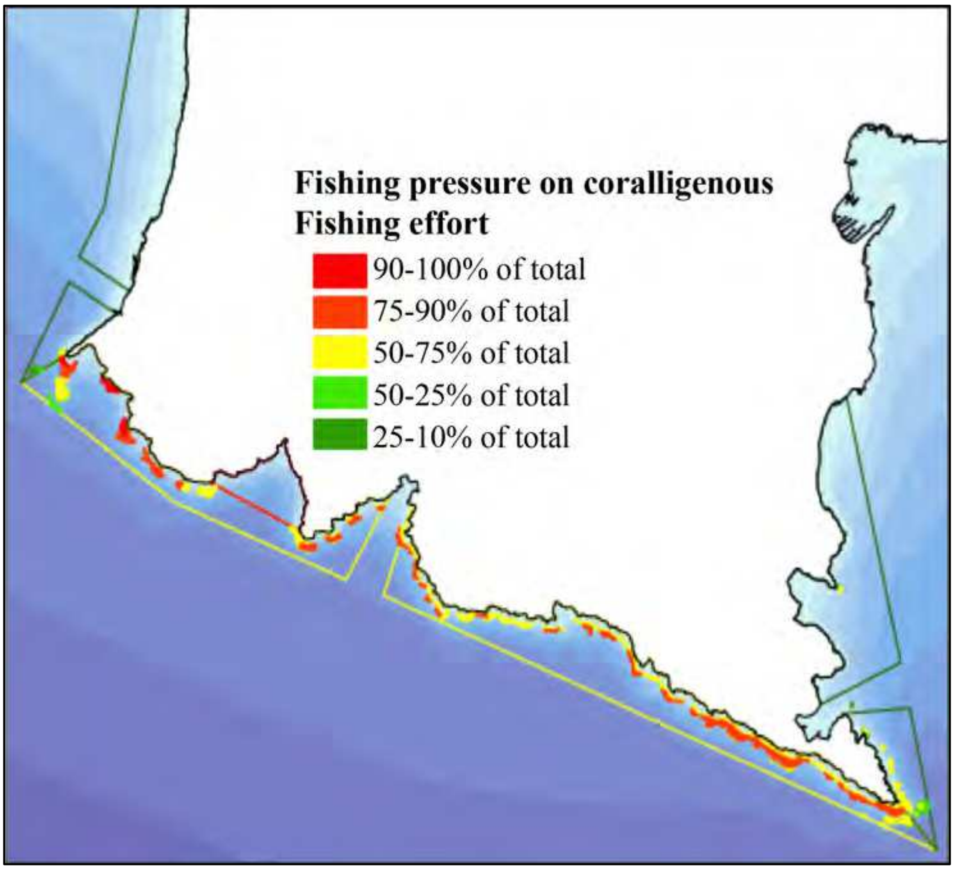


Figure 4: Spatial overlap of coralligenous habitats receiving 90% of total fishing effort in the Portofino MPA.

4.2 Vulnerability assessment

The vulnerability components of coralligenous habitats when is subject to a particular fishing practice is shown in Table 5.

Regarding direct mechanical damage, artisanal fishing nets and bottom longlines (artisanal and recreational) are the most impacting fishing practices, mainly due to the surface they impact and their length, the anchoring of the gear and the general weight of the whole gear that is in direct contact with the seafloor. The high number of hooks of longlines was another important feature of the gear that raises the weight of bottom longlines that could potentially cause abrasion or breaking during the gear retrieval. The regulations of the MPA regarding the length of bottom longlines seems to mitigate the level of the direct damage caused on coralligenous species in the different MPA zones. However, the level of direct damage is not as high as other fishing practices such as trawling and dredging, which are by far the most destructive practices (Bavestrello et al., 2006; Grieves et al., 2014; Sink et al, 2012). In any case, trawling was considered in the evaluation of the vulnerability measures as the worst-case scenario, although trawling is not operating within the study area. Vertical jigging and big game followed with lower potential risk to cause direct damage to coralligenous habitats, but still significant.

	Impact: Direct damage			**Impact: Introduction of non-synthetic compounts (boat use)**	**Impact: resuspension of sediment**			**impact: lost fishing gear**		
	Zone_B	Zone_C	Out_MPA	In/Out_MPA	Zone_B	Zone_C	Out_MPA	Zone_B	Zone_C	Out_MPA
Bottom trolling †	2.5	2.75	2.75	3.5	2.75	2.75	2.75	2	2	2
Pelagic trolling †	0	0	0	3.5	0	0	0	0	0	0
Fishing Cephalopods on boat †	2.5	2.5	2.5	3.25	2.5	2.5	2.5	2	2	2
Bottom Longlines †	2.5	2.75	3	3.25	2.5	2.5	3	3	3	3.75
Pelagic Longlines †	0	0	0	3.25	0	0	0	2.5	2.5	3.25
Vertical jigginng †	2.5	2.5	2.75	3.5	2.5	2.5	2.5	2.5	2.5	2.5
Big game with rod & reel †	2.25	2.5	2.75	3.5	2.5	2.5	2.75	3	3	3
Big game without reel †	2.25	2.5	2.5	3.25	2.5	2.5	2.5	3	3	3
Bottom fishing †	2.5	2.5	2.5	0	2.5	2.5	2.75	3	3	3
Rockfishing †	2.5	2.5	2.5	0	2.5	2.5	2.5	3	3	3
Beach ledgering †	2.5	2.5	2.5	0	2.5	2.5	2.75	3	3	3
Surfacasting †	2.25	2.5	2.5	0	2.5	2.5	2.5	2.25	2.25	2.5
Fishing Cephalopods from coast †	0	0	0	0	0	0	0	2	2	2
Drifting †	0	0	0	3.5	0	0	0	1.75	1.75	1.75
Natelli †	0	0	0	3.25	0	0	0	1.75	1.75	2
Galleggiante †	0	0	0	0	0	0	0	2	2	2
Spinning †	0	0	0	0	0	0	0	1.75	1.75	1.75
Trammel/ Combined nets §	3.5	3.5	3.5	3.75	3.25	3.25	3.25	3.75	3.75	3.75
Gill nets §	3	3	3.25	3.75	3	3	3	3.5	3.5	3.5
Bottom longlines §	2.75	3	3.25	3.75	2.75	2.75	3	3	3	3.75

Table 5: Weighted scores for the different impacts identified for each fishing practice when operating on coralligenous habitats. Symbols indicate (§) artisanal fishing technique; (†) recreational fishing technique

Vertical jigging is a technique practiced with a rod and reel from a boat that could be anchored, and is characterized by the continuous up and down movements of the lure that comes frequently in contact with the seafloor. Big game on the other hand, is always in contact with the seafloor, hence has an impact on the sessile communities of hard substrate directly while fishing, or indirectly through lost lines. Similar were the results regarding the level of impact of sediment re-suspension while a gear is active. This was evaluated based on the weight of the gear or its parts in contact with the seafloor (surrogate for sea bottom penetration), surface of gear in contact with the sea bottom and frequency of contact with sea bottom.

Regarding the impact of introduction of non-synthetic compounds from the use of boats specifically linked with fishing activity, the information available was limited. Therefore for the evaluation of this impact we have considered the engine power and type, the length of boat and the mobility of boat while fishing as the most representative information available for this impact. That was based in the general assumption that recreational boats have smaller engines, new engine technologies (injection) and usually use-unleaded petrol. They rarely exceed the common 5 knotts speed while fishing and they might use the "auxiliary" engine if the boat is light/small enough for fuel economy. On the contrary professional fishermen have greater engine power and use petrol hence, we expect that greater consumption will be in professional fishers, and/or recreational techniques that the gear is active (trolling). Our results are in accordance with this assumption. However for some recreational practices the average length of boat and engine power are high increasing this specific impact.

The impact of lost fishing gear (the whole gear, or parts of it including anchors, lines and weight) that potentially the different techniques may have, was assessed by using as attributes the type, dimensions and number of the gears and hooks allowed in each zone. Trammel and combined nets along with bottom longlines had the highest impact due to the fact that are in direct contact with the seafloor and their length or their surface area where high. However, big game fishing, and all the other practices where the whole or parts of the gear may come in contact with seafloor and/or 3-dimesional structures, the potential for lost fishing gear is also high. Moreover, other fishing practices that are not in contact with the sea bottom, such as pelagic longlines, were also considered to have an impact due to the fact that they are commonly entangled with other gears or are carried away from currents and thus are abandoned.

In all different impacts from fishing on coralligenous it was evident that the regulations of the MPA in most cases were mitigating the level of impact. Hence, in areas outside the MPA, were regulations are softer or inexistent regarding some practices, vulnerability was considerably higher. The confidence levels of the spatial analysis are shown in Fig. 5.

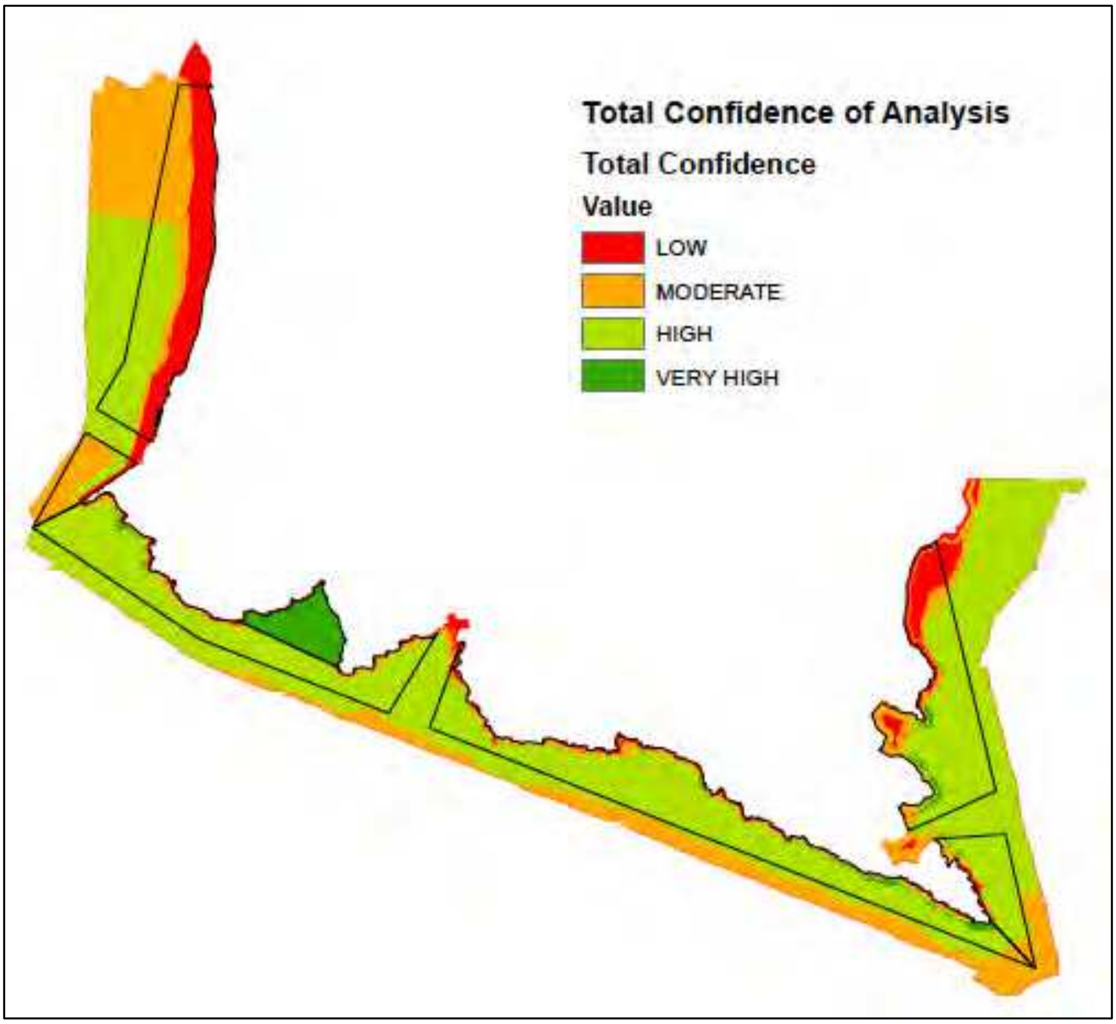


Figure 5: Distribution of confidence level as assessed based on the quality of monitoring information available and the vulnerability scores.

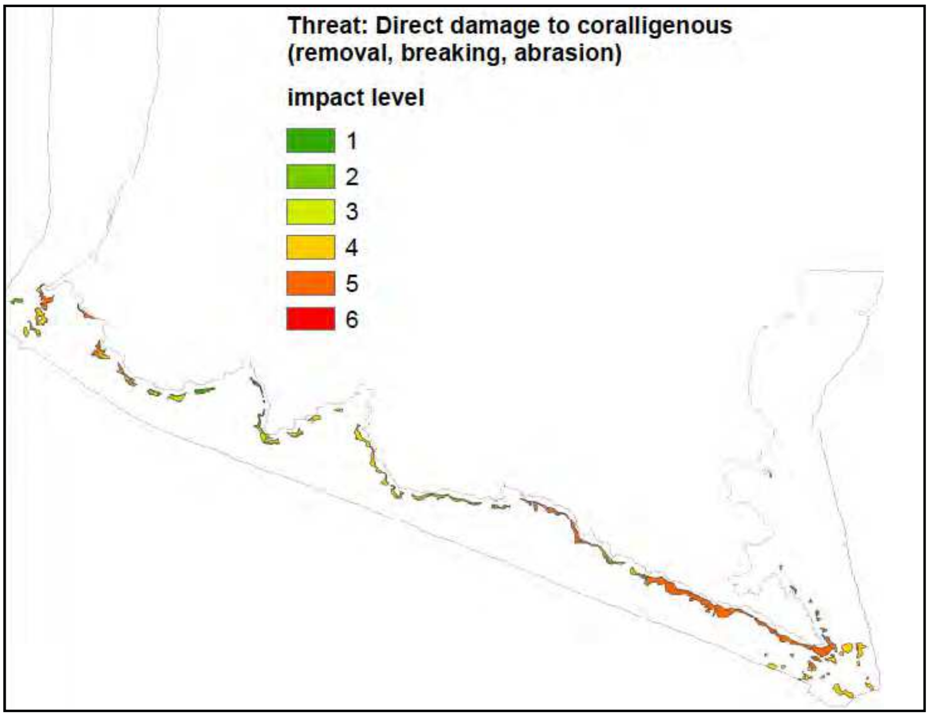
4.3 Cumulative impact assessment

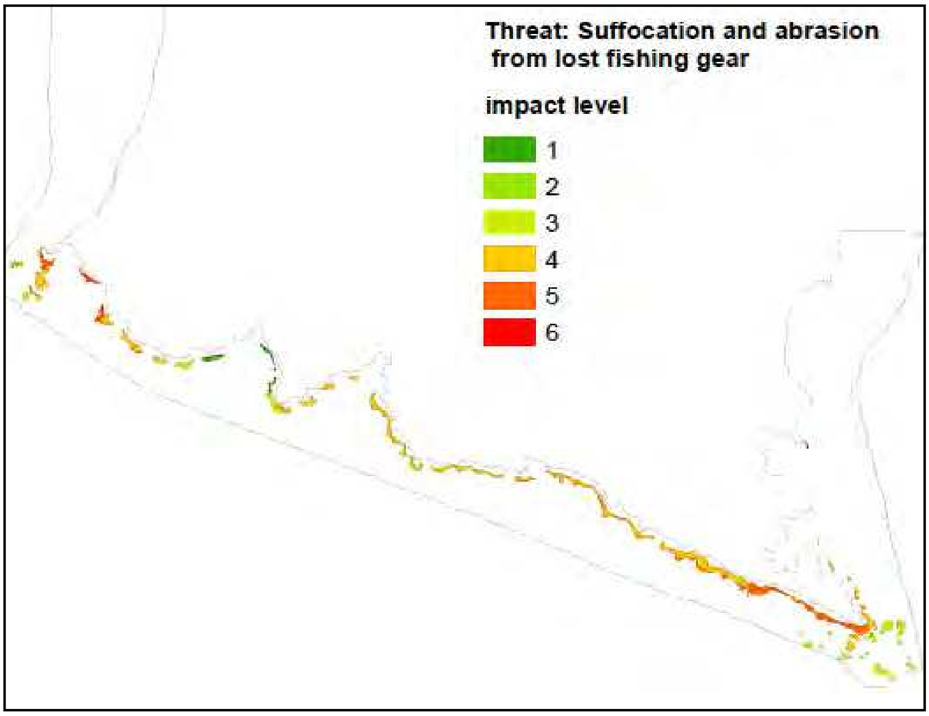
When we multiplied the normalized efforts from the various fishing practices we concluded with four maps that indicated the individual impacts that fishing is causing on coralligenous habitats in the wider area of Portofino MPA.

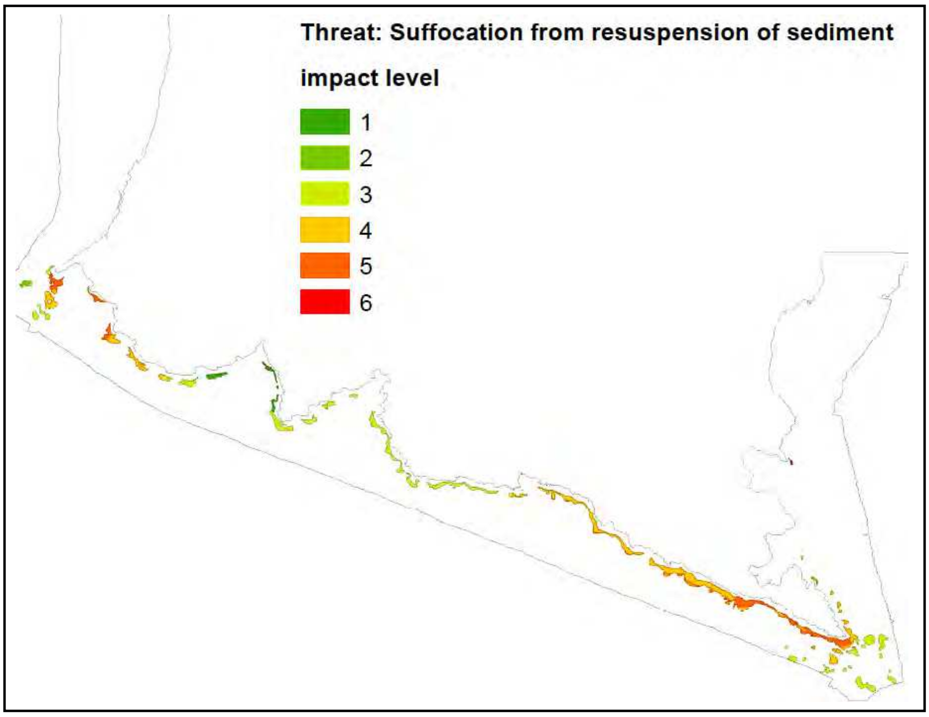
Most impacted area regarding direct mechanical damage (Fig. 6) is the south eastern part of the Promontory, mainly due to the intensive artisanal activity with nets and longlines in this area. These practices target directly benthic fish and thus are in contact with the sea bottom. Gill nets however do not touch the sea bottom, but depending on the target species they may be placed closed to the seafloor or 3-dimesional structures. In general, the south eastern part of the Promontory appears to be much more impacted than the south western part of the Promontory (Punta Chiappa), in contrast to the fact that these areas receive the highest effort as shown before. This is because in Punta Chiappa there is a high recreational fishing activity, however these gears do not cause the level of direct damage as the artisanal fishing that dominates in Punta Faro.

When considering the impact of fishing on coralligenous due to the potential for lost fishing gear though, this fact has the inverse result. More specifically, impacts from lost fishing gear are higher in Punta Chiappa because the recreational activity there is high and is characterised by techniques and gears with a high risk for lost fishing gear. The distribution of the potential impact on coralligenous from re-suspension of sediment due to fishing is similar to the potential for lost fishing gear. Finally the vulnerability of coralligenous due to the use of boats potentially may impact almost the whole surface of the habitat as shown in Fig. 6.

The total cumulative impact assessment, as shown in Fig. 7, identifies the areas of coralligenous that are potentially exposed to a higher pressure due to fishing in comparison to other areas. We notice that the vast majority of coralligenous present in the study area is under a potential threat for degradation or loss, particularly in the depths between 20-50m where coralligenous seems to be more abundant in terms of extend. The reason for this degradation may vary within those areas and could be due to either damage directly for the gear activity and anchoring, or indirectly from the potential lost fishing gear, the pollution from boats and re-suspension of the sediment. We conclude that the outcomes of the analysis revealed new areas that are subject to a potential impact coming from fishing activity in comparison to the simple overlap of the driver and the habitat as is commonly assessed.


Threat: Direct damage to coralligenous
(removal, breaking, abrasion)
impact level
1
2
3
4
5
6


Threat: Suffocation and abrasion
from lost fishing gear
impact level
1
2
3
4
5
6



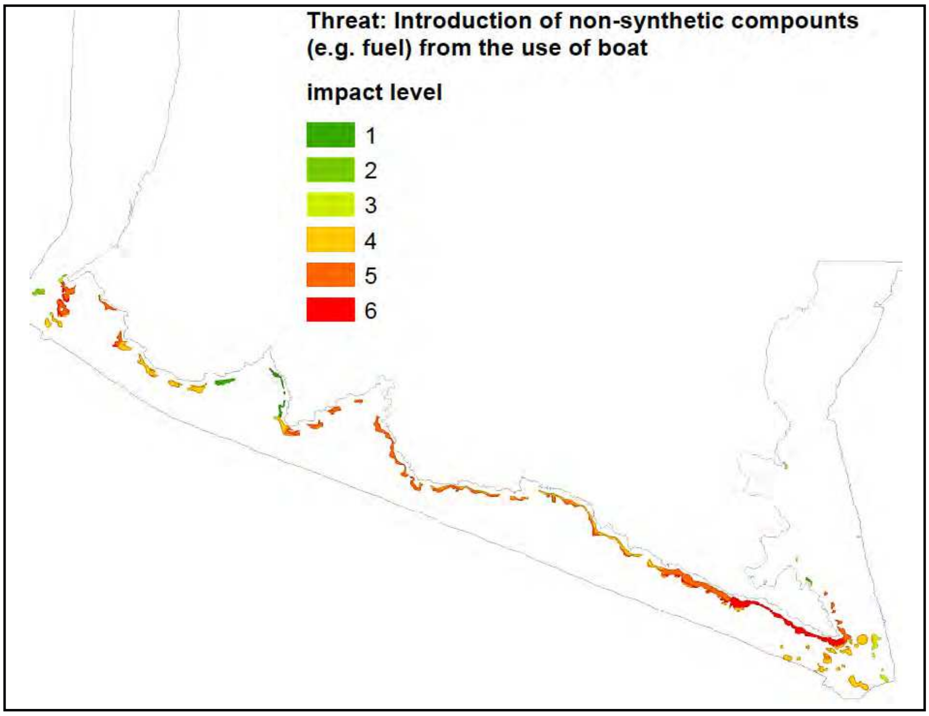


Figure 6: Distribution of the individual level of impacts that recreational and artisanal fishing has on coralligenous habitats present in the wider area of Portofino MPA

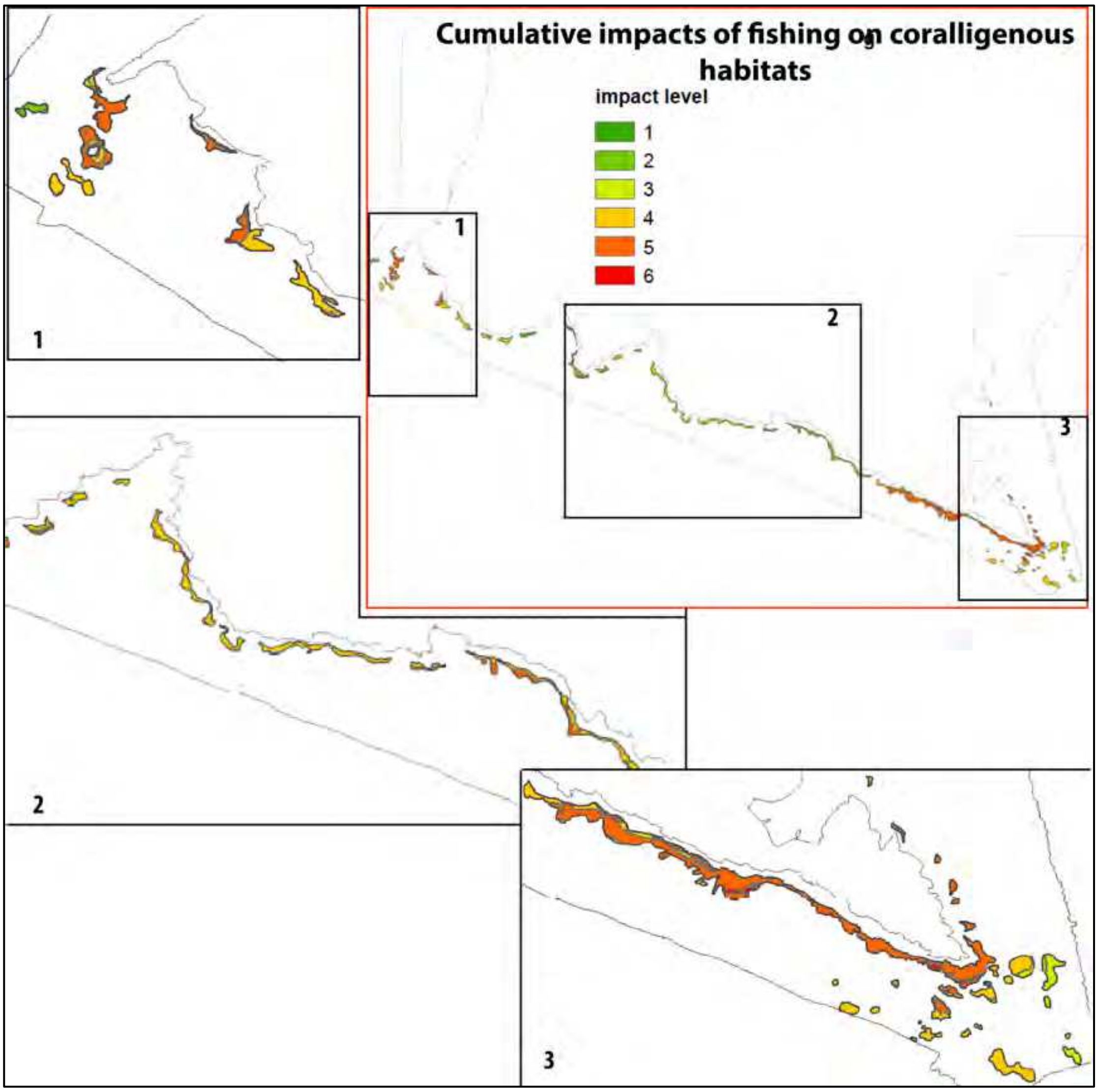


Figure 7: Distribution of the cumulative impacts that recreational and artisanal fishing has on coralligenous habitats present in the wider area of Portofino MPA

5. Discussion

Human activities are progressively rising due to the increased demand for space and resources, resulting on long term unfavourable impacts on marine ecosystems (Halpern et al., 2015). By definition, an ecosystem approach should ideally consider the complete range of interactions that human activities have with the ecosystem and its components (Knights et al., 2015). We have attempted to determine the ecological impact of human activities on benthic vulnerable habitats. We adopted a methodology that demonstrates, quantifies and predicts the effects that recreational and artisanal fishing activity may have on coralligenous in space and time (Elliott, 2002; Martins et al., 2012). We have identified four general categories of impacts that may induce environmental change by causing direct or indirect damage or degradation to coralligenous communities during and after the operation takes place. The method translates the pressures from fishing into ecosystem specific impacts through vulnerability scores that are assessed using quantifiable attributes of fishing practices as surrogates for the different impacts.

The cumulative impacts (Halpern et al., 2007) of recreational and artisanal fishing activities on coralligenous habitats were evaluated in order to provide suggestions for improving the management in Portofino MPA. Three broad aspects have been considered in order to assess the explain the level of a habitat change in terms of loosing a feature or a keystone species after a specific fishing practice has occurred: (i) the severity of the different fishing practices that overlap with the habitat component (spatial extent and frequency of occurrence); (ii) the likely degree of impact that describes the interaction of each fishing technique with coralligenous, or the habitats' vulnerability to that threat; and (iii) the resilience of the habitat in terms of recovery of the habitat once the pressure occurs (Breen et al., 2012; Eastwood et al., 2007; FAO, 2009; Halpern et al., 2007; 2008; Knights et al., 2015; Robinson et al., 2013; Sink et al., 2012).

The whole habitat of coralligenous in Portofino MPA, although of limited spatial extend, is exposed to the fishing footprint. Coralligenous rarity and the fact that a large part of the habitat is located outside the MPA subject to more intensive fishing, makes the habitat highly vulnerable and increases the risk for its potential loss (Sink et al., 2012). The historical perspective and trends of the fishing sector in the wider area confirm that coralligenous has been subject to significant pressure due to the persistence of the activity for the last decades (Bavestrello et al., 1997; Cattaneo-Vietti et al., 2015; Cerrano et al., 2000).

Artisanal fishing had the widest distribution and highest effort in all the study area as expected since those activities are considered traditional in the Ligurian Region, are persistent throughout the year and gears remain for a long period active in the sea, with highest values located outside the MPA in the Gulf of Tigullio. The multi-perspective and relatively high level threats that artisanal fishing poses to coralligenous habitats makes these techniques the most destructive practices amongst the ones examined. The few studies that have attempted to quantify the impacts of static nets on coralligenous have highlighted the destructive capacity of these practices that may damage or remove complex structured organisms, such as gorgonians, at a range from the position of the gears employment while operating or during the gear retrieval (e.g. Grieve et al., 2014; Purroy et al., 2014; Shester and Micheli, 2011). Sampaio et al. (2012) identified the bottom monofilament longlines as a serious threat to gorgonians being entangled in and around the colonies.

The recreational practices of wide spatial extend and high intensity on coralligenous were vertical jigging, big game fishing, and pelagic trolling. Vertical jigging although not a traditional fishing technique of the area, it has had a great acceptance from the sports fishermen and a rapid spread due to its effectiveness in catching large specimens of predatory species such as grouper, amberjack and snapper (Cattaneo-Vietti et al., 2011). The mechanical damage that causes to structurally complex organisms with the lure (weight >200 gr) and the high risk for introduction of invasive species from the use of bait has been reported to other studies (e.g. Cattaneo-Vietti et al., 2011; Portofino MPA, 2009). Fishing with a rod by boat (big game fishing) may cause a serious impact on coralligenous being always in contact with the bottom brings undoubted impact on the communities of both during the action of fishing and the high potential of the practice for lost fishing gear (Portofino MPA, 2009). More specifically, it has been demonstrated that lost lines are responsible for great suffering and often death of the bodies of pre-biotic coralligenous and colonies of sessile tree-form organisms present in coralligenous (Bavestrello et al., 1997). Pelagic trolling although widely distributed as a popular practice in the area has no direct contact to the seafloor. Hence, the only impact identified is the potential for introduction of fuel components such as cyclic hydrocarbons, which is relevantly low. On the contrary, bottom trolling although has a smaller spatial overlap with coralligenous, the nature of the practice poses important threats and impacts on the habitat mainly due to the mobility of the gear, the big weight and its constant contact with the sea bottom, as the vulnerability assessment showed.

The description of the spatial distribution of fishing footprint on benthic habitats has provided only a part of the whole picture regarding fishing impacts. The weighting anthropogenic drivers by their estimated ecological impact resulted in identification of new potentially areas that are subject to high pressures, in comparison to simply mapping the footprints of human activities (Halpern et al., 2008). The impacts from bottom fishing practices have considered being much higher on hard bottom communities of coralligenous than on *Posidonia oceanica,* due to the fragility of key habitat species and their lower recovery potential to recolonize and reestablish after a disturbance (Portofino MPA, 2009; Jennings and Kaiser, 1998; Kaiser and Spencer, 1996; Collie et al., 2002; Thrush and Dayton, 2002; Bavestrello et al., 2006; Cerrano et al., 2010).

Although no clear spatial information exists regarding the health status of coralligenous in the area, scarce information published before verifies the most impacted coralligenous areas by fishing activity in Portofino. Vezzulli et al. (2013) collected data supporting the high vulnerability of gorgonians at depths of 20- 50 m in Portofino MPA as being due to high diving pressure and fishing activity that made them susceptible to bacteria. Management units 6, 15 and 16 at depths of 30-40 m have also been reported in the past for the great amount of lost gear originating from the big game fishing (Cattaneo-Vietti, personal communication). Moreover, the identified areas (e.g. Punta Faro) have been reported to suffer from massive mortality events, implying that cumulative impacts from intensive diving and fishing operating in those ranges have made coralligenous extremely susceptible to climate change effects (Bavestrello et al., 1998; Cerrano et al., 2000; Ponti et al., 2014).

Results suggest that there is a need to manage destructive fishing activities in Portofino MPA. Regulations that are currently set by the MPA showed to be effective, mitigating impact of the activities within zone B and C. However in some cases they did not seem to be adequate enough when considering the cumulating impacts that each practice has. For instance, the length of longlines that is regulated within the Portofino MPA for both artisanal and recreational fishing (maximum 100 hooks in Zone B and 200 hooks in Zone C for recreational, and 200 hooks inside the MPA and 1000 hooks outside the MPA for artisanal), show to be effective regarding causing direct damage to coralligenous, but not regarding lost fishing gear. Inconsistency in the MPA regulations has been also highlighted by Cattaneo-Vietti et al. (2011), which stated contradiction of the length of longlines allowed and the regulation of maximum catch (3 kgr per person per day). Another contradiction in the regulatory framework is the operation of bottom longlines that target protected species (e.g. *Epinephelous emarginatus*) within the MPA while fishing of this species is prohibited.

Prato et al. (in prep.) suggested that the food web recovery in the Portofino MPA may be achieved if recreational fishing is completely forbidden and artisanal fishing activity is reduced by 50%. Although this study focused on the impacts of fishing to benthic habitats, our results support as well the review and strengthening of permit conditions towards limitation of fishing activity to restrict benthic impacts. A possible solution could be the allowance of recreational fishing only during the weekends, or prohibition of destructive fishing practices such as vertical jigging and bottom trolling. Strict mitigation of artisanal nets and bottom longlines is also necessary. Spatial and/or temporal closures after the summer period in the vulnerable areas identified from the cumulative impact analysis are suggested, particularly in the case of increased temperatures this action is expected to limit the likelihood of a massive mortality event on coralligenous (Markantonatou et al., 2015). Monitoring of human activity using advanced technology may provide accurate information on the catch, by-catch and discards of these practices and thus assure better quality of spatial assessments and effective management response (Markantonatou et al., 2014). Long term series data of monitoring fishing activity in combination to indicators regarding the health status spatially defined will assist in setting thresholds that represent in a more efficient way the reality and the peculiarity of the area, its fisheries and biodiversity (Halpern et al., 2007). Aspects such as inspection, the degree to which recreational fishermen accept and comply with the rules and also the economic resources available are key elements in the effectiveness of each MPA (Font et al., 2012). Additional management measures may be applied to strengthen management response, such as consistent retrieval and labeling of gears, organization of regular meetings, promotion of awareness and trust-bonded relations with fishermen (Markantonatou et al., in prep.).

Past efforts to map human impacts on terrestrial ecosystems (Sanderson et al., 2002), coral reefs (Bryant et al, 1998), and coastal regions (Ban and Alder, 2008; Beck and Odaya, 2001) used either coarse categorical or ad hoc methods to translate human activities into impacts. Other attempts that have moved towards a more integrating approach (e.g. Hobday et al., 2007; 2011; Knights et al., 2015; Purroy et al., 2014; Smith et al., 2007; Williams et al., 2011; Weaver et al., 2011) have focused either to a single-pressure (e.g. trawling), or have grouped fishing activities in clusters with similar features, loosing an important part of heterogeneity between fishing practices and their impacts. In MPAs where commercial fishing for example is prohibited, a more detailed approach is necessary to discriminate impacts between the less destructive activities (Williams et al., 2011). In the cases that fishing activities and their impacts are discriminated and evaluated separately, the assessments may be poor neglecting important pressure and state indicators, or there is inconsistency of results due to the expert judgment.

We have developed a standardized, quantitative method that takes into account the heterogeneity of techniques and captures the different scale of impacts on benthic habitats in a systematic way. Although it has been adjusted for serving the needs of an MPA, the method is flexible enough to be applied in any area and incorporate different ecological components. It recognizes uncertainty, includes the precautionary approach, introduces the vulnerability of a habitat due to a human threat, and stresses the societal, social and economic dimensions of the ecosystem approach and the need for equity (Garcia et al., 2014). Another advantage of the approach is that attributes and vulnerability scores for different impacts are measured relatively independently.

Using a structured, transparent and repeatable analysis under a holistic perspective, the vulnerability and cumulative impacts assessment accounts for issues and may provide advice even if there is little data available (Robinson et al., 2013). This is because all existing knowledge, information and defensible data can be integrated into a scientifically sound and defensible concept (Sink et al., 2012). However, it is suggested that in the absence of information or cases of uncertainty, one perspective of best practice is to manage known or unknown risks with caution (Grieve et al., 2014).

A wide range of multi-scale data is required to describe the vulnerability of the system, the interactions of ecosystems and human pressures, and the cumulative impacts, which are typically limited or entirely lacking (Williams et al., 2011). The lack of accurate species distribution has limited the capacity of the approach in order to spatially assess the vulnerability of the coralligenous at the species level. However, the use of spatial data with attributes that represent reasonable proxies were available at some point and assisted in identifying high threat areas (Foley et al., 2013). The cumulative impact assessment currently relies on assumptions of linear and additive responses of natural systems to stressors, although recent studies have shown that relationships can be non-linear and act synergistically and mitigative, rather than additive (Crain et al., 2008). In any case the information is currently insufficient information to allow incorporation of these relationships into the cumulative impact assessment (Halpern et al., 2015). Moreover, the method does not take into account the cumulative impacts from other activities known to take lace on the habitat (e.g. diving, beach replenishment, temperature anomalies other sources of pollution etc.) that may increase the potential risk by delaying the species recovery, or even cancel it completely. Therefore, it is expected that when considering impacts from other activities the habitats resilience to decrease, as it has been showed amongst others by (Cerrano et al., 2005; Vezzulli et al., 2013). In this step, it is important to highlight the gaps of information and suggest that further research is necessary to improve the understanding of potential benthic impacts in hard bottom communities and the life cycles of key habitat species' that may improve the quality of the assessment in the future. In addition, more detailed information regarding specific impacts and species response to the different pressures (i.e. abrasion, mechanical damage, etc.) is believed to improve the results of the present analysis and develop more accurate thresholds for indicators that trigger evaluation and adaptation of habitats (Foley et al., 2013).

Pressure-impact assessments have been increasingly seen as away to integrate science, policy, and management and has been widely used to address a range of environmental issues (e.g. Giakoumi et al., 2015; Hobday et al., 2011; Knights et al., 2015; Samhouri and Levin, 2012). We have suggested a combination of useful tools that integrate ecological, management and policy interventions and can be easily applied and communicated by managers in a straightforward way. We highly recommend that the vulnerability and cumulative impact assessment should be deliberated with stakeholders that can make an important contribution by providing expert judgment, fishery-specific and ecological knowledge, and process and outcome ownership (Hobday et al., 2007). Managers may benefit by the evaluation of the degree to which human activities interfere with the achievement of management objectives, and improve the structure and focus their efforts into more targeted conservation strategies. The produced vulnerability score may provide baseline information for conservation planning and support further assessment that takes into account a wider range of human activities and ecosystems and the implementation of good practice.

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References

Angiolillo, M., Lorenzo, B.D., Farcomeni, A., Bo, M., Bavestrello, G., Santangelo, G., Cau, A., Mastascusa, V., Cau, A., Sacco, F., Canese, S., 2015. Distribution

and assessment of marine debris in the deep Tyrrhenian Sea (NW Mediterranean Sea, Italy). Mar. Pollut. Bull. 92, 149–159. doi:10.1016/j.marpolbul.2014.12.044
Balata, D., Piazzi, L., Cecchi, E., Cinelli, F., 2005. Variability of Mediterranean coralligenous assemblages subject to local variation in sediment deposition. Marine Environmental Research 60, 403–421. doi:10.1016/j.marenvres.2004.12.005
Ballesteros, E., 2006. Mediterranean Coralligenous Assemblages, Oceanography and Marine Biology - An Annual Review, A Synthesis of Present Knowledge. CRC Press. doi:10.1201/9781420006391.ch4
Ban, N., Alder, J., 2008. How wild is the ocean? Assessing the intensity of anthropogenic marine activities in British Columbia, Canada. Aquatic Conserv: Mar. Freshw. Ecosyst. 18, 55–85. doi:10.1002/aqc.816
Barbera, C., Bordehore, C., Borg, J.A., Gl marec, M., Grall, J., Hall-Spencer, J.M., la Huz, de, C., Lanfranco, E., Lastra, M., Moore, P.G., Mora, J., Pita, M.E., Ramos-Espl, A.A., Rizzo, M., S nchez-Mata, A., Seva, A., Schembri, P.J., Valle, C., 2003. Conservation and management of northeast Atlantic and Mediterranean maerl beds. Aquatic Conserv: Mar. Freshw. Ecosyst. 13, S65–S76. doi:10.1002/aqc.569
Bavestrello, G., Bertone, S., Cattaneo-vietti, R., Cerrano, C., 1994. Mass mortality of *Paramuricea clavata* (Anthozoa, Cnidaria) on Portofino Promontory cliffs, Ligurian Sea, Mediterranean Sea, Mar. Life 4, 15-19.
Bavestrello, G., Cerrano, C., Zanzi, D., Cattaneo-Vietti, R., 1997. Damage by fishing activities to the Gorgonian coral *Paramuricea clavata* in the Ligurian Sea. Aquatic Conserv: Mar. Freshw. Ecosyst. 7, 253–262. doi:10.1002/(SICI)1099-0755(199709)7:3<253::AID-AQC243>3.0.CO;2-1
Beck, M.W., Odaya, M., 2001. Ecoregional planning in marine environments: identifying priority sites for conservation in the northern Gulf of Mexico. Aquatic Conserv: Mar. Freshw. Ecosyst. 11, 235–242. doi:10.1002/aqc.449
Bo, M., Bava, S., Canese, S., Angiolillo, M., Cattaneo-Vietti, R., Bavestrello, G., 2014. Fishing impact on deep Mediterranean rocky habitats as revealed by ROV investigation. Biological Conservation 171, 167–176. doi:10.1016/j.biocon.2014.01.011
Bourcier, M., 1986. Evolution, en cinq années, des herbiers à Posidonia oceanica et du macrobenthos circalittoral action conjuguée des activités humaines et des modifications climatiques, Vie et milieu 36, 1-8.
Breen, P., Robinson, L.A., Rogers, S.I., Knights, A.M., Piet, G., 2012. An environmental assessment of risk in achieving good environmental status to support regional prioritisation of management in Europe. Marine Policy 36, 1033–1043. doi:10.1016/j.marpol.2012.02.003
Bryant, D., Burke, L., McManus, J., Spalding, M., 1998. Reefs at Risk: A Map-Based Indicator of Threats to the World's Coral Reefs. World Resources Institute, Washington, DC.
Cabral, P., Levrel, H., Schoenn, J., Thiébaut, E., Le Mao, P., 2014. Marine habitats ecosystem service potential: A vulnerability approach in the Normand-Breton (Saint Malo) Gulf, France. Ecosystem Services 16, 306–318. doi:10.1016/j.ecoser.2014.09.007
Cattaneo-Vietti, R., Cappanera, V., Castellano, M., Povero, P., 2015. Yield and catch changes in a Mediterranean small tuna trap: a warming change effect? Mar Ecol 36, 155–166. doi:10.1111/maec.12127
Cattaneo-Vietti, R., Campodonico ,P., Cappanera, V., 2011. La pesca ricreativa nelle

AMP liguri. MARTE+ project, Regione Liguria. 11pp.
Cerrano, C., Arillo, A., Azzini, F., Calcinai, B., Castellano, L., Muti, C., Valisano, L., Zega, G., Bavestrello, G., 2005. Gorgonian population recovery after a mass mortality event. Aquatic Conserv: Mar. Freshw. Ecosyst. 15, 147–157. doi:10.1002/aqc.661
Cerrano, C., Bavestrello, G., Bianchi, C.N., Cattaneo-vietti, R., Bava, S., Morganti, C., Morri, C., Picco, P., Sara, G., Schiaparelli, S., Siccardi, A., Sponga, F., 2000. A catastrophic mass mortality episode of gorgonians and other organisms in the Ligurian Sea (North western Mediterranean), summer 1999. Ecology Letters 3, 284–293. doi:10.1046/j.1461-0248.2000.00152.x
Cerrano, C., Danovaro, R., Gambi, C., Pusceddu, A., Riva, A., Schiaparelli, S., 2010. Gold coral (*Savalia savagli*a) and gorgonian forests enhance benthic biodiversity and ecosystem functioning in the mesophotic zone. Biodivers Conserv 19, 153–167. doi:10.1007/s10531-009-9712-5
Cinelli F, Balata D, Piazzi L (2007) Threats to coralligenous assemblages: sedimentation and biological invasions. Hydrobiol 398(399):91–100
Cocito, S., 2004. Bioconstruction and biodiversity: their mutual influence. Sci. Mar. 68. doi:10.3989/scimar.2004.68s1137
Cohen, Y., Nissenbaum, A., Eisler, R., 1977. Effects of Iranian crude oil on the Red Sea octocoral Heteroxenia fuscescens. Environmental Pollution (1970) 12, 173–186. doi:10.1016/0013-9327(77)90051-9
Collie, J.S., Escanero, G.A., Valentine, P.C., 2000. Photographic evaluation of the impacts of bottom fishing on benthic epifauna. ICES J. Mar. Sci. 57, 987–1001. doi:10.1006/jmsc.2000.0584
Crain, C.M., Kroeker, K., Halpern, B.S., 2008. Interactive and cumulative effects of multiple human stressors in marine systems. Ecology Letters 11, 1304–1315. doi:10.1111/j.1461-0248.2008.01253.x
Davies, A.J., Duineveld, G.C.A., Lavaleye, M.S.S., Bergman, M.J.N., van Haren, H., Roberts, J.M., 2009. Downwelling and deep□water bottom currents as food supply mechanisms to the cold□water coral Lophelia pertusa (Scleractinia) at the Mingulay Reef Complex. Limnology and Oceanography 54, 620–629. doi:10.4319/lo.2009.54.2.0620
DeLeo, D.M., Ruiz-Ramos, D.V., Baums, I.B., 2015. Response of deep-water corals to oil and chemical dispersant exposure. Deep Sea Research Part II: Topical Studies in Oceanography. doi:10.1016/j.dsr2.2015.02.028
Desvousges, W., Mathews, K., Train, K., 2012. Adequate responsiveness to scope in contingent valuation. Ecological Economics 84, 121–128. doi:10.1016/j.ecolecon.2012.10.003
Dounas, C., Davies, I., Triantafyllou, G., Koulouri, P., Petihakis, G., Arvanitidis, C., Sourlatzis, G., Eleftheriou, A., 2007. Large-scale impacts of bottom trawling on shelf primary productivity. Continental Shelf Research 27, 2198–2210. doi:10.1016/j.csr.2007.05.006
Eastwood, P.D., Mills, C.M., Aldridge, J.N., Houghton, C.A., Rogers, S.I., 2007. Human activities in UK offshore waters: an assessment of direct, physical pressure on the seabed. ICES J. Mar. Sci. 64, 453–463. doi:10.1093/icesjms/fsm001
E.C., 2008. Commission Decision of 6 November 2008 adopting a multiannual Community programme pursuant to Council Regulation (EC) No 199/2008 establishing a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the

Common Fisheries Policy (2008/949/EC). O.J.E.U., L346.
EC, 2008. Commission Regulation (EC) No 665/2008 of 14 July 2008 laying down detailed rules for the application of Council Regulation (EC) No 199/2008 concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy, O.J.E.U., L186.
Elliott, M., 2014. Integrated marine science and management: wading through the morass, Marine pollution bulletin. Marine pollution bulletin. doi:10.1016/j.marpolbul.2014.07.026
Elliott, M., 2002. The role of the DPSIR approach and conceptual models in marine environmental management: an example for offshore wind power, Marine pollution bulletin. Marine pollution bulletin. doi:10.1016/s0025-326x(02)00146-7
Etnoyer, P.J., Wickes, L.N., Silva, M., Dubick, J.D., Balthis, L., Salgado, E., MacDonald, I.R., 2015. Decline in condition of gorgonian octocorals on mesophotic reefs in the northern Gulf of Mexico: before and after the Deepwater Horizon oil spill. Coral Reefs 1–14. doi:10.1007/s00338-015-1363-2
FAO, 2009. The State of World Fisheries and Aquaculture: 2008, FAO Food and Agriculture Organization of the United Nations. Rome.
Fisher, C.R., Demopoulos, A.W.J., Cordes, E.E., Baums, I.B., White, H.K., Bourque, J.R., 2014. Coral Communities as Indicators of Ecosystem-Level Impacts of the Deepwater Horizon Spill. BioScience 64, 796–807. doi:10.1093/biosci/biu129
Fletcher, W.J., Shaw, J., Metcalf, S.J., Gaughan, D.J., 2010. An ecosystem based fisheries management framework: the efficient, regional-level planning tool for management agencies. Marine Policy 34, 1226–1238. doi:10.1016/j.marpol.2010.04.007
Foley, M.M., Armsby, M.H., Prahler, E., Caldwell, M.R., Erickson, A., Kittinger, J.N., Crowder, L.B., Levin, P.S., 2013. Improving Ocean Management through the Use of Ecological Principles and Integrated Ecosystem Assessments. BioScience 63, 619–631. doi:10.1525/bio.2013.63.8.5
Font, T., Lloret, J., Piante, C., 2012. Recreational fishing within Marine Protected Areas in the Mediterranean. MedPAN North Project WWF France.
Garrabou, J., Ballesteros, E., 2000. Growth of Mesophyllum alternans and *Lithophyllum frondosum* (Corallinales, Rhodophyta) in the northwestern Mediterranean. European Journal of Phycology 35, 1–10. doi:10.1080/09670260010001735571
Garrabou, J., Harmelin, J.G., 2002. A 20-year study on life-history traits of a harvested long-lived temperate coral in the NW Mediterranean: insights into conservation and management needs. J Anim Ecol 71, 966–978. doi:10.1046/j.1365-2656.2002.00661.x
Giakoumi, S., Halpern, B.S., Michel, L.N., Gobert, S., Sini, M., Boudouresque, C.F., Gambi, M.C., Katsanevakis, S., Lejeune, P., Montefalcone, M., Pergent, G., Pergent Martini, C., Sanchez Jerez, P., Velimirov, B., Vizzini, S., Abadie, A., Coll, M., Guidetti, P., Micheli, F., Possingham, H.P., 2015. Towards a framework for assessment and management of cumulative human impacts on marine food webs. Conservation Biology 29, 1228–1234. doi:10.1111/cobi.12468
Gili, J.M., Coma, R., 1998. Benthic suspension feeders: their paramount role in littoral marine food webs. Trends Ecol. Evol. (Amst.) 13, 316–321. doi:10.1016/S0169-5347(98)01365-2
Grieve, C., Brady, D.C., Polet, H., 2014. Best practices for managing, measuring and mitigating the benthic impacts of fishing. Marine Stewardship Council Science

Series 2, 18–88.
Halpern, B.S., Frazier, M., Potapenko, J., Casey, K.S., Koenig, K., Longo, C., Lowndes, J.S., Rockwood, R.C., Selig, E.R., SELKOE, K.A., Walbridge, S., 2015. Spatial and temporal changes in cumulative human impacts on the world's ocean. Nature Communications 6, 7615. doi:10.1038/ncomms8615
Halpern, B.S., SELKOE, K.A., Micheli, F., KAPPEL, C.V., 2007. Evaluating and ranking the vulnerability of global marine ecosystems to anthropogenic threats. Conservation Biology 21, 1301–1315. doi:10.1111/j.1523-1739.2007.00752.x
Halpern, B.S., Walbridge, S., SELKOE, K.A., KAPPEL, C.V., Micheli, F., D'Agrosa, C., Bruno, J.F., Casey, K.S., Ebert, C., Fox, H.E., Fujita, R., Heinemann, D., Lenihan, H.S., Madin, E.M.P., Perry, M.T., Selig, E.R., Spalding, M., Steneck, R., Watson, R., 2008. A global map of human impact on marine ecosystems. Science 319, 948–952. doi:10.1126/science.1149345
Heifetz, J., Stone, R.P., Shotwell, S.K., 2009. Damage and disturbance to coral and sponge habitat of the Aleutian Archipelago. Mar. Ecol. Prog. Ser. 397, 295–303. doi:10.3354/meps08304
Hobday, A.J., Smith, A.D.M., Stobutzki, I.C., Bulman, C., Daley, R., Dambacher, J.M., Deng, R.A., Dowdney, J., Fuller, M., Furlani, D., Griffiths, S.P., Johnson, D., Kenyon, R., Knuckey, I.A., Ling, S.D., Pitcher, R., Sainsbury, K.J., Sporcic, M., Smith, T., Turnbull, C., Walker, T.I., Wayte, S.E., Webb, H., Williams, A., Wise, B.S., Zhou, S., 2011. Ecological risk assessment for the effects of fishing. Fisheries Research 108, 372–384. doi:10.1016/j.fishres.2011.01.013
Hobday, A.J., Smith, A., Webb, H., Daley, R., Wayte, S., Bulman, C., Dowdney, J., 2007. Ecological Risk Assessment for the Effects of Fishing: Methodology, Australian Fisheries Management Authority. Canberra.
Hong, J.S., 1982. Contribution à l"étude des peuplements d"un fond de concrétionnement Coralligène dans la région marseillaise en Méditerranée nord-occidentale. Ocean and Polar Research.
Jennings, S., Kaiser, M., 1998. The Effects of Fishing on Marine Ecosystems. Advances in Marine Biology 34, 201–352. doi:10.1016/s0065-2881(08)60212-6
Jennings, S., Pinnegar, J.K., Polunin, C., Warr, K.J., 2001. Impact of trawling disturbance on the trophic structure of benthic invertebrate communities. Mar. Ecol. Prog. Ser. 213, 127–142.
Kaiser, M.J., Spencer, B.E., 1996. The effects of beam-trawl disturbance on infaunal communities in different habitats. J Anim Ecol 65, 348. doi:10.2307/5881
Kaiser, M.J., 1998. Significance of Bottom-Fishing Disturbance. Conservation Biology 12, 1230–1235. doi:10.1046/j.1523-1739.1998.0120061230.x
Kaiser, M.J., Ramsay, K., Richardson, C.A., Spence, F.E., Brand, A.R., 2000. Chronic fishing disturbance has changed shelf sea benthic community structure. J Anim Ecol 69, 494–503. doi:10.1046/j.1365-2656.2000.00412.x
Kaiser, M.J., Collie, J.S., Hall, S.J., Jennings, S., Poiner, I.R., 2003. Impacts of fishing gear on marine benthic habitats., Responsible fisheries in the marine ecosystem. CABI, Wallingford. doi:10.1079/9780851996332.0197
Knights, A.M., Piet, G.J., Jongbloed, R.H., Tamis, J.E., White, L., Akoglu, E., Boicenco, L., Churilova, T., Kryvenko, O., Fleming-Lehtinen, V., Leppanen, J.-M., Galil, B.S., Goodsir, F., Goren, M., Margonski, P., Moncheva, S., Oguz, T., Papadopoulou, K.N., Setälä, O., Smith, C.J., Stefanova, K., Timofte, F., Robinson, L.A., 2015. An exposure-effect approach for evaluating ecosystem-wide risks from human activities. ICES J. Mar. Sci. 72, 1105–1115. doi:10.1093/icesjms/fsu245

Kružić, P., 2014. Bioconstructions in the Mediterranean: Present and Future, in: The Mediterranean Sea. Springer Netherlands, Dordrecht, pp. 435–447. doi:10.1007/978-94-007-6704-1_25

Kryvenko, O., Vyacheslav, S., Churilova, T., Mazik, K., Little, S., Barnard, S., Elliott, M., 2014. Generic and sea- specific pressure- impact link matrices.

Kushmaro, A., Henning, G., Hofmann, D.K., 1997. Metamorphosis of Heteroxenia fuscescens planulae (Cnidaria: Octocorallia) is inhibited by crude oil: a novel short term toxicity bioassay. Marine Environmental Research 43, 295–302. doi:10.1016/s0141-1136(96)00092-x

Laborel, J., 1987. Marine biogenic constructions in the Mediterranean, a review. Scientific Reports of Port-Cros national Park 13, 97–127.

Leslie, H.M., McLeod, K.L., 2007. Confronting the challenges of implementing marine ecosystem-based management. Frontiers in Ecology and the Environment 5, 540–548. doi:10.1890/060093

Levin, P.S., Fogarty, M.J., Murawski, S.A., Fluharty, D., 2009. Integrated ecosystem assessments: developing the scientific basis for ecosystem-based management of the ocean. PLoS Biol. 7, e14. doi:10.1371/journal.pbio.1000014

Linares, C., Doak, D.F., Coma, R., Díaz, D., Zabala, M., 2007. Life history and viability of a long-lived marine invertebrate: the octocoral *Paramuricea clavata*. Ecology 88, 918–928.

Lloret, J., Zaragoza, N., Caballero, D., Riera, V., 2008. Impacts of recreational boating on the marine environment of Cap de Creus (Mediterranean Sea). Ocean & Coastal Management 51, 749–754. doi:10.1016/j.ocecoaman.2008.07.001

MacDonald, D.S., Little, M., Eeno, N.C., Hiscock, K., 1996. Disturbance of benthic species by fishing activities: a sensitivity index. Aquatic Conserv: Mar. Freshw. Ecosyst. 6, 257–268. doi:10.1002/(SICI)1099-0755(199612)6:4<257::AID-AQC194>3.0.CO;2-7

Markantonatou, V., Marconi, M., Cappanera, V., Campodonico, P., Bavestrello, A., Cattaneo-Vietti, R., Papadopoulou, N., Smith, C., Cerrano, C., 2014. Spatial allocation of fishing activity on coralligenous habitats in Portofino MPA (Liguria, Italy), in: Bouafif, C., Langar, H., Ouerghi, A. (Eds.). Presented at the UNEP/MAP- RAC/SPA, Proceedings of the second Mediterranean Symposium on the conservation of Coralligenous and other Calcareous Bio-Concretions. Portorož, Slovenia, 29-30 October 2014, Portorož, Slovenia, pp. 118–123.

Markantonatou, V., Marconi, M., Cerrano, C. Susceptibility assessment of seafloor to lost fishing gear in data poor areas in prep.

Markantonatou, V., Marconi, M., Cerrano, C., 2015. Guidelines for monitoring pressure and impacts from small scale and recreational fishing activity in Mediterranean Marine Protected Areas, Deliverable ITN MMMPA Project, Ancona.

Martins, J.H., Camanho, A.S., Gaspar, M.B., 2012. A review of the application of driving forces – Pressure – State – Impact – Response framework to fisheries management. Ocean & Coastal Management 69, 273–281. doi:10.1016/j.ocecoaman.2012.07.029

Miller, K.J., Neil, H., Tracey, D., 2009. Recent advances in deep-sea coral science and emerging links to conservation and management of deep-sea ecosystems. Mar. Ecol. Prog. Ser. 397, 1–5. doi:10.3354/meps08452

Passow, U., Ziervogel, K., Asper, V., Diercks, A., 2012. Marine snow formation in the aftermath of the Deepwater Horizon oil spill in the Gulf of Mexico. Environmental Research Letters 7, 035301. doi:10.1088/1748-9326/7/3/035301

Piazzi, L., Gennaro, P., Balata, D., 2012. Threats to macroalgal coralligenous assemblages in the Mediterranean Sea. Mar. Pollut. Bull. 64, 2623–2629. doi:10.1016/j.marpolbul.2012.07.027

Piet, G.J., Jongbloed, R.H., Knights, A.M., Tamis, J.E., 2015. Evaluation of ecosystem-based marine management strategies based on risk assessment. Biological Conservation 186, 158–166. doi:10.1016/j.biocon.2015.03.011

Ponti, M., Perlini, R.A., Ventra, V., Grech, D., Abbiati, M., Cerrano, C., 2014. Ecological shifts in Mediterranean coralligenous assemblages related to gorgonian forest loss. PLoS ONE 9, e102782. doi:10.1371/journal.pone.0102782

Portofino MPA, 2009. La pesca professionale nell'AMP Portofino. 30pp. Retrieved from (03.05.2014) www.portofinoamp.it/it/images/stories/upload3/relazione%20finale%20impatto%202009-66-95.pdf

Puig, P., Canals, M., Company, J.B., Martín, J., Amblas, D., 2012. Ploughing the deep sea floor. Nature 489, 286–289. doi:10.1038/nature11410

Purroy, A., Requena, S., Gili, J.M., 2014. Spatial assessment of artisanal fisheries and their potential impact on the seabed: the Cap de Creus regional case study (northwestern Mediterranean Sea). Sci. Mar. 78, 449–459. doi:10.3989/scimar.04000.21a

Reed, J.K., 2002. Deep-water Oculina coral reefs of Florida: biology, impacts, and management. Hydrobiologia 471, 43–55. doi:10.1023/A:1016588901551

Reed, J.K., Koenig, C.C., Shepard, A.N., 2007. Impacts of bottom trawling on a deep-water Oculina coral ecosystem off Florida. Bulletin of Marine Science.

Robinson, L.A., White, L., Culhane, F., Knights, A.M., 2013. ODEMM Pressure Assessment Userguide V.2.

Sala, E., Ballesteros, E., Dendrinos, P., Di Franco, A., Ferretti, F., Foley, D., Fraschetti, S., Friedlander, A., Garrabou, J., Güçlüsoy, H., Guidetti, P., Halpern, B.S., Hereu, B., Karamanlidis, A.A., Kizilkaya, Z., Macpherson, E., Mangialajo, L., Mariani, S., Micheli, F., Pais, A., Riser, K., Rosenberg, A.A., Sales, M., SELKOE, K.A., Starr, R., Tomas, F., Zabala, M., 2012. The structure of Mediterranean rocky reef ecosystems across environmental and human gradients, and conservation implications. PLoS ONE 7, e32742. doi:10.1371/journal.pone.0032742

Salomidi, M., Katsanevakis, S., Borja, A., Braeckman, U., Damalas, D., Galparsoro, I., Mifsud, R., Mirto, S., Pascual, M., Pipitone, C., Rabaut, M., Todorova, V., Vassilopoulou, V., Fernandez, T.V., 2012. Assessment of goods and services, vulnerability, and conservation status of European seabed biotopes: a stepping stone towards ecosystem-based marine spatial management. Mediterranean Marine Science 13, 49–88. doi:10.12681/mms.23

Samhouri, J.F., Levin, P.S., 2012. Linking land-and sea-based activities to risk in coastal ecosystems. Biological Conservation 145, 118–129. doi:10.1016/j.biocon.2011.10.021

Sanderson, E.W., Jaiteh, M., Levy, M.A., Redford, K.H., Wannebo, A.V., Woolmer, G., 2002. The Human Footprint and the Last of the Wild The human footprint is a global map of human influence on the land surface, which suggests that human beings are stewards of nature, whether we like it or not. BioScience 52, 891–904. doi:10.1641/0006-3568(2002)052[0891:THFATL]2.0.CO;2

Sartoretto, S., Francour, P., 1997. Quantification of bioerosion by *Sphaerechinus granularis* on coralligene concretions of the western Mediterranean. Oceanographic Literature Review.

Sherwood, O.A., Heikoop, J.M., Scott, D.B., 2005. Stable isotopic composition of deep-sea gorgonian corals Primnoa spp.: a new archive of surface processes. Mar Ecol 301, 135–148. doi:10.3354/meps301135
Shester, G.G., Micheli, F., 2011. Conservation challenges for small-scale fisheries: Bycatch and habitat impacts of traps and gillnets. Biologocal Conservation 144, 1673–1681. doi:10.1016/j.biocon.2011.02.023
Silva, M., Etnoyer, P.J., MacDonald, I.R., 2015. Coral injuries observed at mesophotic reefs after the Deepwater Horizon oil discharge. Deep Sea Research Part II: Topical Studies in Oceanography. doi:10.1016/j.dsr2.2015.05.013
Sink, K.J., Wilkinson, S., Atkinson, L.J., Sims, P.F., Leslie, R.W., Attwood, C.G., 2012. The potential impacts of South Africa's demersal hake trawl fishery on benthic habitats: historical perspectives, spatial analyses, current review and potential management actions, South African National Biodiversity Institute.
Smith, A., Hobday, A.J., Webb, H., Daley, R., Wayte, S., Bulman, C., Dowdney, J., Williams, A., Sporcic, M., Dambacher, J., Fuller, M., Furlani, D., Walker, T., 2007. Ecological Risk Assessment for the Effects of Fishing. Final Report R04/1072 for the Australian Fisheries Management Authority, Australian Fisheries Management Authority. Canberra.
Smith, C., Papadopoulou, N., Barnard, S., Mazik, K., Patrício, J., Elliott, M., Solaun, O., Little, S., Borja, A., Bhatia, N., Moncheva, S., Robele, S., Can Bizsel, K., Eronat, A.H., 2014. Conceptual models for the effects of marine pressures on biodiversity. DEVOTES, WP 1. Deliverable 1.1.
Stone, R.P., 2006. Coral habitat in the Aleutian Islands of Alaska: depth distribution, fine-scale species associations, and fisheries interactions. Coral Reefs 25, 229–238.
Sulak, K., Berg, J., Randall, M., Dennis, G.D., III, 2008. Dual-Carbon sources fuel the OCS deep-reef Community, a stable isotope investigation, in:. Presented at the Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida, ReefBase, Penang, Malaysia, p.5.
Thrush, S.F., Dayton, P.K., 2002. Disturbance to Marine Benthic Habitats by Trawling and Dredging: Implications for Marine Biodiversity. Annu. Rev. Ecol. Syst. 33, 449–473. doi:10.1146/annurev.ecolsys.33.010802.150515
Tunesi, L., Peirano, A., Romeo, G., Sassarini, M., 1991. Problématiques de la protection des fàcies à Gorgonaires sur les fonds côtiers de "Cinque Terre"(Mer Ligure, Italie). GIS Posidonie, Marseille.
UNEP, 2007. *Draft Action Plan on Protecting the Coralligenous and other Calcareous Bio-Concretions in the Mediterranean*. UNEP DEPI MED WG. 308/14, 18.
UNEP-MAP, RAC/SPA, 2015. Draft updated Action Plan for the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea. Tunisia.
Vezzulli, L., Pezzati, E., Huete-Stauffer, C., Pruzzo, C., Cerrano, C., 2013. 16SrDNA Pyrosequencing of the Mediterranean Gorgonian Paramuricea clavata Reveals a Link among Alterations in Bacterial Holobiont Members, Anthropogenic Influence and Disease Outbreaks. PLoS ONE 8, e67745. doi:10.1371/journal.pone.0067745
Weaver, P.P.E., Benn, A., Arana, P.M., Ardron, J.A., Bailey, D.M., Baker, K., Billett, D.S.M., Clark, M.R., Davies, A.J., Durán Muñoz, P., Fuller, S.D., Gianni, M., Grehan, A.J., Guinotte, J., Kenny, A., Koslow, J.A., Morato, T., Penney, A.J., Perez, J.A.A., Priede, I.G., Rogers, A.D., Santos, R.S., Watling, L., 2011. The

impact of deep-sea fisheries and implementation of the UNGA Resolutions 61/105 and 64/72. Southampton.
Wheeler, A.J., Bett, B.J., Billett, D., 2005. The impact of demersal trawling on northeast Atlantic deepwater coral habitats: the case of the Darwin Mounds, United Kingdom. American ….
Widdicombe, S., Austen, M.C., Kendall, M.A., 2004. Importance of bioturbators for biodiversity maintenance: indirect effects of fishing disturbance. Mar Ecol 275, 1–10. doi:10.3354/meps275001
Williams, A., Dowdney, J., Smith, A., Hobday, A.J., 2011a. Evaluating impacts of fishing on benthic habitats: a risk assessment framework applied to Australian fisheries. Fisheries Research 112, 154–167. doi:10.1016/j.fishres.2011.01.028

Chapter V

Seafloor susceptibility assessment for lost fishing gears, in data poor areas

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Abstract

One of the main threats to coastal marine areas is lost fishing gears (LFG) that finally end up on the sea bottom impacting the ecological, economic and to some extent aesthetic value of an area, if it is popular to diving activity. Allocation and immediate retrieval of LFG is a key issue in coastal Marine Protected Areas that usually use divers to take action. In order to identify areas that are potentially susceptible to LFG we have applied a semi-quantitative spatial analysis using information provided by volunteer divers in the Portofino MPA (Ligurian sea, Italy). The output map indicates accurately the areas that are more susceptible in accumulating lost fishing gear considering sea bottom morphology and fishing activity as driving components of the impact's presence. The outcomes of the present study aim to assist managers, divers and scientists in providing accurate information that will guide monitoring and retrieval of LFG.

Keywords: abandoned gear; lost fishing gear; topography; Marine Protected Areas; spatial analysis

1. Introduction

One of the main threats in the Mediterranean Sea is the presence of marine debris. It has been estimated that from 6.4 million tones of marine debris that are inputted to global seas annually (UNEP, 2005), about 70% of sinks to the sea-bottom (FAO, 2010), and 10% of it is comprised of discarded fishing gear (EEA, 2014).

Fishing gears have direct and indirect long term impacts on the marine environment and its organisms when they are lost in the environment (Brown and Macfadyen, 2007; Matsuoka et al., 2005). Fishing gear may be lost, discarded or abandoned if it comes into contact with another gear (e.g. pelagic longlines), fisher's mishandlings, or improper gear designs and materials (Antonelis et al., 2011; Cho, 2009; FAO, 2010; Santos et al., 2003). It can be also lost when snagged on submerged features with complex three-dimensional structures, such as rocks, outcrops, biogenic reefs, or calcareous organisms (Ayaz et al., 2010; Macfadyen et al., 2009; Pawson, 2003; Vanderlaan and Smedbol, 2011). If the lost gear is not retrieved and is carried away during bad weather or strong currents, it is considered abandoned or lost (Gilman, 2015). Finally, many fishermen on purpose abandon their gears if they are detected whilst fishing illegally, or discard unwanted parts of the gear at sea (Gilman, 2015; Imamura, 2011).

Lost fishing gear (LFG) is considered marine litter and is only recently that this problem has been officially identified as a threat that should be monitored and managed (MSFD 2008/56/EC, Descriptor 10 "Marine litter"). Particularly in Marine Protected Areas (MPAs), the monitoring and retrieval of LFG is of extreme importance for the marine conservation and the sustainable economy of the area. Direct monitoring of LFG usually includes snorkelers or volunteer scuba divers in shallow areas, where the retrieval and quantification of gears is possible. Indirect attempts to provide quantitative information on marine litter have been made through visual information from videos or photos obtained through volunteer scuba divers in coastal waters, or with the use of sonar, ROVs and AUVs in deeper waters (e.g. (Angiolillo et al., 2015; Bo et al., 2014; Fabri et al., 2014; Heifetz et al., 2009; Mordecai et al., 2011; Watters et al., 2010). These approaches are preferred, as they can be the least damaging monitoring approaches in comparison to the trawling method (Gage and Roberts, 2005). Indirect monitoring methods (e.g. ROV, satellite images) advance in being applicable at all types of sea-bottoms reaching great depths and accuracy, but are expensive and no direct measure to retrieve LFG can be made (Spengler and Costa, 2008).

LFG results in an increased and persistent threat to the wildlife that extends for a long period of time (Brown and Macfadyen, 2007; Gunn et al., 2010). The rapid expansion of fishing effort on new fishing grounds and the transition to synthetic, more durable and buoyant materials of fishing gears have expanded the issue of lost gears in the marine environment (Derraik, 2002; Gilardi et al., 2010). Fishing gear when lost will drift in the water column until will end up on the sea bottom. Its presence on both sea column and seafloor has serious impacts on fish stocks and megafauna, such as seabirds, sea turtles, marine mammals, elasmobranchs and some bony fishes. It may lead to an organism's demising by entangling and wounding, causing sub-lethal effects and restricting their movement to avoid predators or forage (Gilman, 2015; Good et al., 2010; Rodríguez et al., 2013; Tasker et al., 2000;

Uhlmann et al., 2005; Wilcox et al., 2015; Zabka et al., 2006).

LFG has also been reported to pose a hazard and long term impacts to shallow and deep critical habitats that represent foraging areas, fish spawning grounds, turtle nesting areas and migration routes of important species (Brown and Macfadyen, 2007; Gilman, 2015; Matsuoka et al., 2005). It has been shown that abandoned gears such as lines, nets and anchors, may cause direct physical damage to benthic organisms (Donohue et al., 2001; Kaiser et al., 2003). When dragged, it can scour and abrade the sea bed and associated communities, including sensitive habitats like coastal seagrass beds and biogenic reefs, and benthic cold water coral reefs and sponge fields (Gilardi et al., 2010; Markantonatou et al., 2014). Fragile three-dimensional benthic species can be adversely damaged, removed or broken under the pressure of heavy drifting nets (Grieve et al., 2014). Metals from weights and non-biodegradable synthetic fibers make the gears persistent in the environment (Gunn et al., 2010). Lead in fishing weights also accumulate in marine food webs (Moore, 2008; Thompson et al., 2004). LFG can entrap fine sediment smothering benthic communities, and may develop fouling that accumulates covering large proportions of areas causing suffocation to the communities below due to prevention of gas exchange (Macfadyen et al., 2009; UNEP, 2009).

LFG causes important economic damage to the local community, for instance by impacting fish stocks and fishery profits (Gunn et al., 2010). Gilardi et al. (2010) calculated a loss of $19656 to the Dungeness crab commercial fishery due to the entanglement of crabs during the lifetime of a gill net, in comparison to the $1358 cost of removing the gillnets yielding a cost-benefit ratio of 1:14.5. It can also harm business such as diving tourism and impede navigation, introduce alien species and cause aesthetic degradation of the marine environment (Macfadyen et al., 2009; Spengler and Costa, 2008). There is an important economic investment in retrieving gears from the sea bottom and beach clean up projects (Macfadyen et al., 2009).

Studies have shown that although LFG may be found in all types of sea bottoms, and high abundances occur on hard substrates where complex rocky habitats occur (Watters et al., 2010). Areas characterized by high geomorphological and topographical features, ecological complexity and high biodiversity of three-dimensional species such as gorgonians, sponges and corals have also been correlated with accumulation of higher percentages of litter (Pham and Stewart, 2014; Schlining et al., 2013; Woodall et al., 2015). Areas characterized by geomorphological hot-spot biodiversity features are well known that are often a targets for fisheries (Clark and Koslow, 2007). Other factors that have a role in the location of lost gear settlement are the distance to the coast (Barnes et al., 2009; Mordecai et al., 2011; Pham and Stewart, 2014), hydrology (Galgani et al., 1996) and fishing intensity (Bergmann and Klages, 2012; Markantonatou et al., 2014; Ramirez-Llodra et al., 2011).

The aims of the present study were to identify areas that are potentially susceptible to lost fishing gear. Semi-quantitative spatial analysis has been applied using information provided by volunteer divers that retrieve the LFG in the Portofino MPA (Ligurian Sea, Italy). The analysis considers the sea bottom morphology and fishing effort as driving factors of LFG accumulation. Results provide concrete and accurate geo-referenced information that may assist MPA managers to monitor and take action by removing LFG from the sea bottom using volunteer divers. Removal of LFG will secure the good environmental status of the marine environment promoting the goods and services in terms of ecologic, economic and aesthetic value that vulnerable habitats provide.

3. Methods

The approach combines qualitative assessment of LFG and distribution of LFG casual factors in order to predict the probability to find LFGs across a geographic area. The method allows for the calculation of a LFG hazard index based on the weighted scores of the casual factors. Similar methodologies are common in the field of natural hazard assessment (Islam and Sado, 2000; El Morjani et al. 2007). The approach moves through the implementation of the subsequent stages: (i) identification and data collection of the casual factors; (ii) classification and map distribution of the LFG in the target area; (iii) estimation of the weighted score for each casual factors by crossing them with the LFG map and standardization of the weighted scores; and (iv) aggregation and classification of the resulting map to obtain the allotment of the accumulation degree of LFG.

1.1 Causal factor identification and data collection

The following nine casual factors were identified as the most important elements able to describe the susceptibility of a specific area to accumulate LFG:

(i) *Depth* represents the bathymetry of the area, and it has been interpolated using the coastline, bathymetric lines from the Region Liguria, and the DEM derived from multibeam data (Zapata et al, submitted) with a spatial resolution of 1 metre. All the other variables following, derived from the DEM using the Benthic Terrain Modeler in ESRI ArcGIS software (Wilson et al, 2007)

(ii) *Slope* measures in degrees the steepness of a certain area

(iii) *Slope over slope* is a measure of the magnitude of slope change. It was calculated from the slope layer

(iv) *Curvature* displays the shape of the slope, concave (positive curvature) or convex (negative curvature). A value of zero indicates that the curvature is linear (Gallant and Wilson, 2000). It was calculated from the DEM

(v) *Eastness* represents the degree of exposure to east of a certain area. In particular, it is the sine of the angles (in radians) of the azimuthal direction of the steepest slope at the centre of a certain area (Hirzel et al., 2002; Patthey, 2003; Wilson et al., 2007)

(vi) *Northness* represents the degree of exposure to north of a certain area. In particular, it is the cosine of the angles (in radians) of the azimuthal direction of the steepest slope at the centre of a certain area (Hirzel et al., 2002; Patthey, 2003; Wilson et al., 2007)

(vii) *Benthic Position Index* (BPI) derived from the topographic position index used for geomorphologic purposes on land (Weis, 2001). BPI was calculated for each cell in a DEM grid by comparing the elevation of the cell to the mean elevation of the surrounding cells in an annulus (inner and outer radius measure five and seventy-five metres respectively). Positive BPI values indicate that the central point is located higher than its average surroundings, while negative values indicate a position lower than the average. Null BPI values connote a flat area

(viii) *Rugosity* is a measure of irregularity of a certain surface. Operatively, it was measured by the ratio of the surface area to a flat planar area of the same geometric surface area (Wilson et al., 2007)

(ix) *Distance from coastline* represents the distance in metres from the coastline.

Since no information on currents exist, we have considered Eastness and Northness as surrogates of the exposed areas to eastwards or northwards currents that are known to exist in the area.

3.2 Lost Fishing Gear distribution and classification

The spatial distribution of the LFG in the Portofino MPA is based on the visual census during LFG retrieval undertaken by volunteer divers (pers comm. Bruno Borelli, Portofino Divers Association). The census was performed in 2013-2014 in six diving sites in the Portofino MPA to a distance of 100 metres from the buoy where diving is allowed. The divers used the observed LFG abundance found in each diving site as a surrogate of the "level of impact". They classified the level of impact in four levels: not impacted (absence of LFG), low impact, moderate impact, and very impacted. The data was provided based on the diver's depth and position from the buoy. Using ArcGIS the position of buoys were reported, buffers of 100 meter were drawn around each of them, and were divided in 25 sectors to which the levels of LFG abundance were assigned, as shown in Fig. 1. Divers did not report information on the type and weight of gear found.

3.3 Casual factor classification, weighted score estimation and standardization

Each casual factor was classified into nine ordinal classes following the Jenks natural breaks classification method (Jennks, 1967). This method determined the break points between different classes, by reducing the variance within classes and maximizes the variance between classes. Then, the causal factors were weighted based on their spatial correlation with the distribution of the LFG abundance. In detail, by crossing the classified LFG abundance distribution map with each causal factor grid the area percentage of each class was obtained according to the LFG abundance classes. The weighted score for each class was then calculated as the sum of the products between the area percentages of the class for each GFG abundance level.

Operatively the following equation was applied:

$$Weighted\ score\ = (a) + (3b) + (5c)$$

Where *a, b* and *c* correspond to the area percentage of the casual factor class examined in areas with low abundance LFG ("a"), moderate abundance LFG ("b") and very high abundance LFG ("c") respectively. Once the weighted scores for all casual factors' classes had been calculated, they were standardized and rescaled into ordinal classes according to a scale from 1 to 10 indicating classes with the lowest (1) or highest (10) likelihood for a LFG occurrence in the given area.

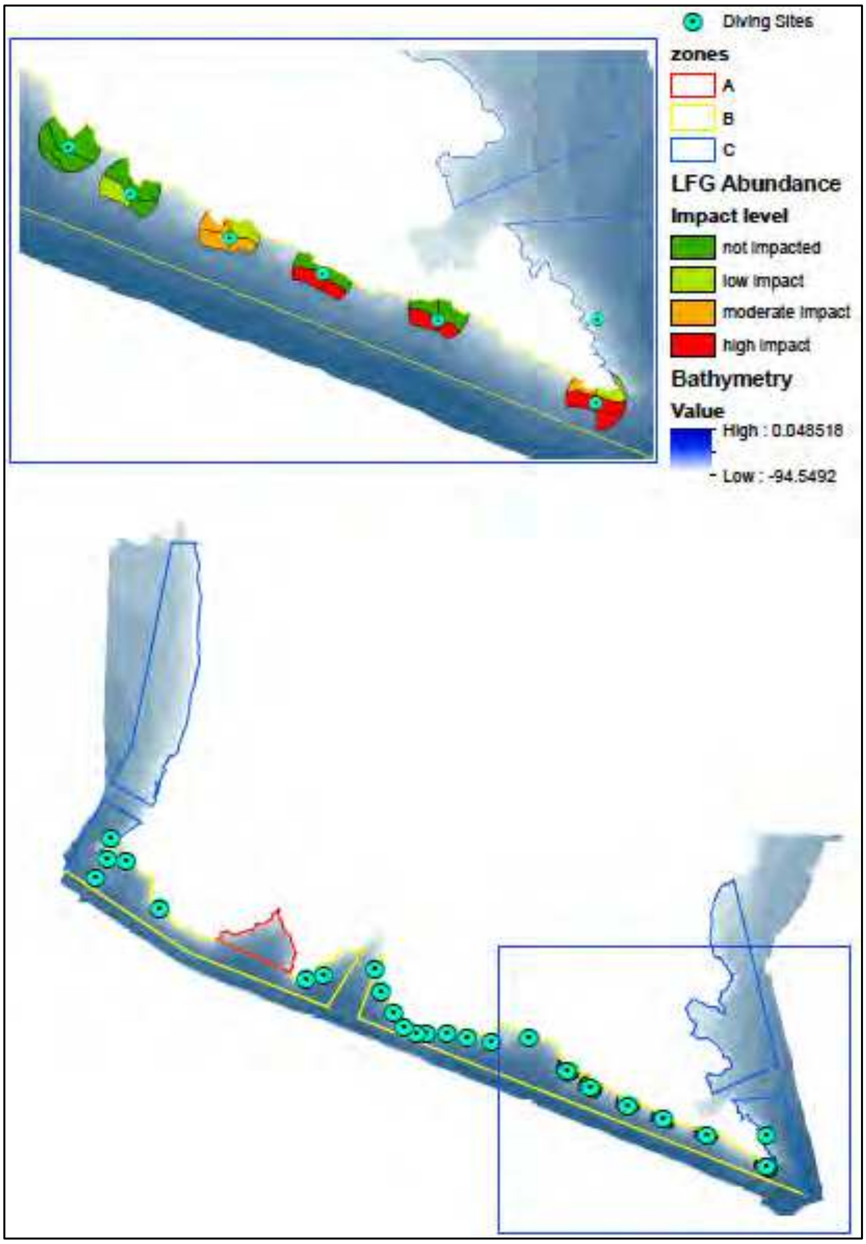

Fig. 1. Study area of the Portofino MPA, diving sites sampled in 25 sectors and their recorded status of accumulating LFG

3.4 Data aggregation and map of LFG hazard

We conducted a Principal Component Analysis (PCA) in order to select non-correlated causal factors to define the area's capacity to accumulate LFG. From the PCA we concluded in 7 total components (depth; Northness; Eastness; slope; BPI; rugosity; and curvature) to include in the analysis. Each causal factor distribution map was reclassified to contain the distribution of the corresponding standardized weighted score before being combined using the multiplicative overlay method in

ESRI ArcGIS. Eastness and Northness, representing the exposure of the area to water currents, were transformed in order to represent the exposure of the coast to water currents. In detail, the study area was divided in eighteen subdivisions each one with a length of approximately 700 metres. For each subdivision the median aspect was calculated (the most frequent value of aspect rounded to 5°). Thus, the aspect values were modified in order to represent the relative exposure to the median one of the considered subdivision. The aspect values in the area eastward from Punta Faro were rotated by 150° and 135°. The aspect values of the westward from Punta Chiappa were rotated by -60° and -135° (positive value represent a clockwise rotation, and vice versa for the negative rotation), as shown in Fig. 2. For each cell, the method multiplies the score of all the casual factors together to produce the distribution of the LFG hazard index. Finally, the LFG hazard index distribution map was classified into five intensity degrees (very low, low, medium, high, and very high) using a natural breaks scheme.

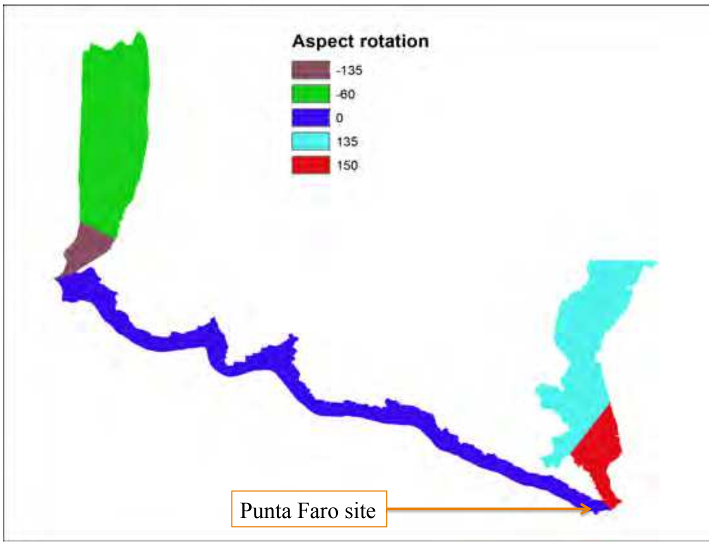

Fig. 2. Modification of aspect values to represent the relative exposure to water currents

4. Results

The susceptibility assessment indicated the parameters that have a major role at the distribution of LFG in the Portofino MPA.

4.1 Depth and distance from coast

The depth (Table 1) showed a general positive relation to the abundance of LFG. More specifically, in depths shallower than 31 m there is a low impact, while in depths between 31-58m the impact is moderate. Deeper than 58m a higher accumulation of LFG was noted. Distance from coast (Table 2) in general agrees with the trend of bathymetry where in shallower and closer to the coast areas there is less gear susceptibility in comparison to deeper waters and more distant from coast areas (>34 m distance). More specifically, results show that highest accumulation of LFG was mainly between 45-80 m from the coastline, and moderate to high in areas of distance 8-130 m and 34-45m from coast.

Table 1. Results of spatial analysis regarding bathymetry

		Sum of ghost gear impact level				Total Sum	% of ghost gear impact level				weighted score	Sum of Weighted Scores
variable category	Depth classes	value_0	value_1	value_3	value_5	sum	value_0	value_1	value_3	value_5	WS	SWS
depth_1	-67.951912 - -57.942522	0	0	0	1271	1271	0.00	0.00	0.00	100.00	500.00	10
depth_2	-57.942522 - -50.567182	1918	0	0	1880	3798	50.50	0.00	0.00	49.50	247.50	5
depth_3	-50.567182 - -44.245463	3053	2214	3110	8422	16799	18.17	13.18	18.51	50.13	319.39	6
depth_4	-44.245463 - -37.923743	4132	1594	2631	8067	16424	25.16	9.71	16.02	49.12	303.35	6
depth_5	-37.923743 - -31.075213	4698	1737	2399	7023	15857	29.63	10.95	15.13	44.29	277.79	6
depth_6	-31.075213 - -23.963278	9284	2298	1779	1158	14519	63.94	15.83	12.25	7.98	92.47	2
depth_7	-23.963278 - -17.114748	11695	3237	1455	0	16387	71.37	19.75	8.88	0.00	46.39	1
depth_8	-17.114748 - -10.529624	12261	2737	1874	0	16872	72.67	16.22	11.11	0.00	49.54	1
depth_9	-10.529624 - -0.783639	8483	1522	1689	0	11694	72.54	13.02	14.44	0.00	56.35	1

min	46.39043	1
max	500	10
slope	0.019841	
intercept	0.079574	

Table 2. Results of spatial analysis regarding distance from coast.

		Sum of ghost gear impact level				Total Sum	% of ghost gear impact level				weighted score	Sum of Weighted Scores
variable category	Distance classes	value_0	value_1	value_3	value_5	sum	value_0	value_1	value_3	value_5	WS	SWS
distancecoast_1	0 - 11.401754	10601.00	3240.00	2756.00	0.00	16597.00	63.87	19.52	16.61	0.00	69.34	1
distancecoast_2	11.401754 - 22.847319	10086.00	2631.00	1911.00	676.00	15304.00	65.90	17.19	12.49	4.42	76.74	1
distancecoast_3	22.847319 - 34.234486	9248.00	2062.00	1540.00	2413.00	15263.00	60.59	13.51	10.09	15.81	122.83	3
distancecoast_4	34.234486 - 45.453274	6800.00	1428.00	1748.00	4541.00	14517.00	46.84	9.84	12.04	31.28	202.36	7
distancecoast_5	45.453274 - 56.648037	4846.00	1154.00	2197.00	5994.00	14191.00	34.15	8.13	15.48	42.24	265.77	9
distancecoast_6	56.648037 - 68.09552	3881.00	1234.00	2312.00	6083.00	13510.00	28.73	9.13	17.11	45.03	285.60	10
distancecoast_7	68.09552 - 80.659782	3529.00	1459.00	1743.00	4278.00	11009.00	32.06	13.25	15.83	38.86	255.05	9
distancecoast_8	80.659782 - 96.104111	3416.00	1238.00	418.00	2443.00	7515.00	45.46	16.47	5.56	32.51	195.70	6
distancecoast_9	96.104111 - 129.031006	1950.00	579.00	0.00	1393.00	3922.00	49.72	14.76	0.00	35.52	192.35	6

min	69.33783	1
max	285.6033	10
slope	0.041616	
intercept	-1.88553	

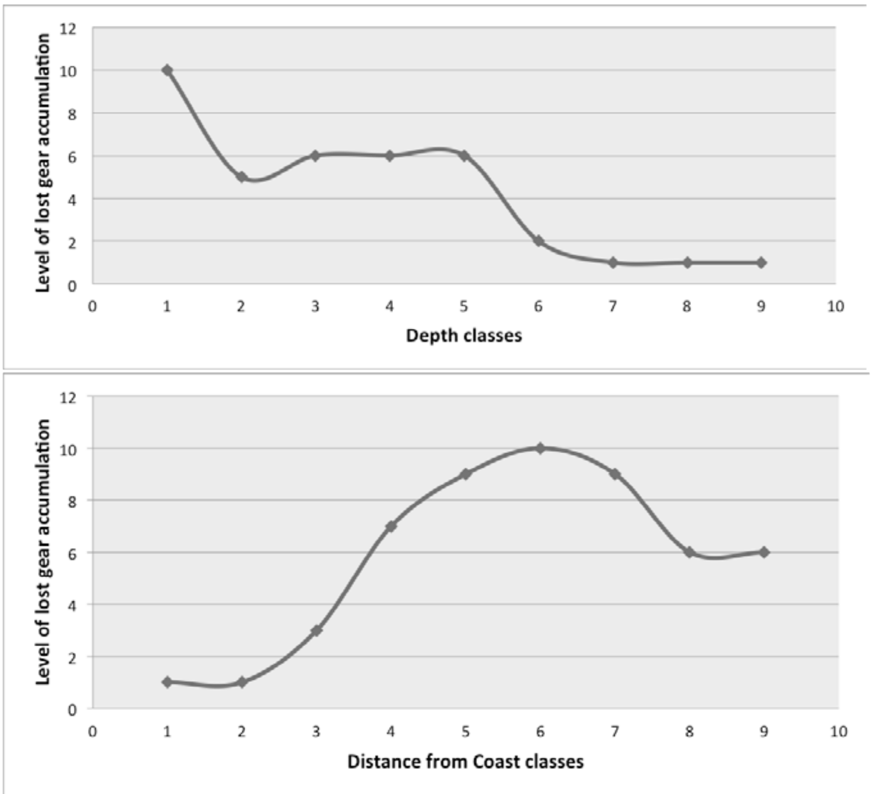

Fig. 3. Variation of depth and distance from coast variables with accumulation of lost fishing gear

4.2 Curvature

Curvature (Table 3) indicated that the highest abundance of LFG was noted in relative flat areas, characterized by small convex and concave topography, and higher accumulation towards negative values (convex). This indicates that gear tends to be more concentrated in the sides of the curvatures rather than on the top of convex. However, it is expected that concaves will accumulate LFG on the contrary with the results of the analysis. This could be probably due to the assumption that the reported abundance of gear covers the whole surface of a diving site quadrant in combination to the high variability of seafloor morphology of the area on those depths.

Table 3. Results of spatial analysis regarding the curvature.

		Sum of ghost gear impact level				Total Sum	% of ghost gear impact level				weighted score	Sum of Weighted Scores
variable category	Curvature classes	value_0	value_1	value_3	value_5	sum	value_0	value_1	value_3	value_5	WS	SWS
curvature_1	-382.634918 - -137.56736	277	91	49	30	447	61.969	20.358	10.962	6.7114	86.80089	1
curvature_2	-137.567362 - -71.005804	1557	491	221	323	2592	60.069	18.943	8.5262	12.461	106.8287	2
curvature_3	-71.005804 - -34.699499	5506	1470	878	1611	9465	58.172	15.531	9.2763	17.021	128.4628	4
curvature_4	-34.699499 - -10.495296	12048	3038	2808	5011	22905	52.6	13.263	12.259	21.877	159.4281	6
curvature_5	-10.495296 - 10.683381	17925	4947	7464	15573	45909	39.045	10.776	16.258	33.921	229.1577	10
curvature_6	10.683381 - 37.91311	11352	3381	2444	3602	20779	54.632	16.271	11.762	17.335	138.2309	4
curvature_7	37.91311 - 83.29599	5024	1487	805	1338	8654	58.054	17.183	9.3021	15.461	122.3943	3
curvature_8	83.29599 - 158.934125	1532	363	219	280	2394	63.993	15.163	9.1479	11.696	101.086	2
curvature_9	158.934125 - 388.874054	303	71	49	53	476	63.655	14.916	10.294	11.134	101.4706	2

min	86.80089	1
max	229.1577	10
slope	0.063221	
intercept	-4.48768	

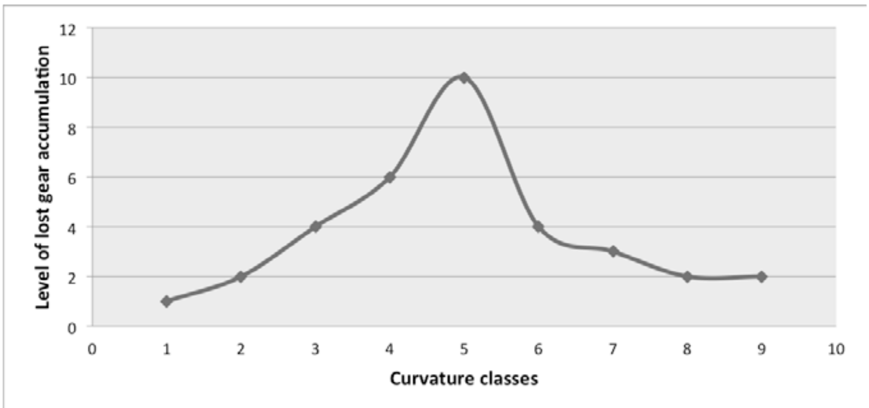

Fig. 4. Variation of curvature with accumulation of lost fishing gear

4.3 Eastness and Northness

Eastness and Northness (Tables 4 and 5 respectively) have been used as surrogates of current flow direction. In Eastness, the negative values (<0) indicate westerly, and positive values (>0) indicate easterly direction of geomorphological structures. The variable does not show clear response, since information from LFG comes only from the south-eastern part of the promontory of the MPA and not from the whole MPA. In contrast, Northness shows a good response as a variable. In Northness the negative values (<0) indicate south and positive values (>0) indicate northerly exposure of geomorphological structures (Fig. 5). A high accumulation of LGI is mainly located in the southern part, while in the north we have no impact, as expected because the orientation of sea bottom towards the north is protected from the water currents.

Table 4. Results of spatial analysis regarding the eastness

		Sum of ghost gear impact level				Total Sum	% of ghost gear impact level				weighted score	Sum of Weighted Scores
variable category	Eastness classes	value_0	value_1	value_3	value_5	sum	value_0	value_1	value_3	value_5	WS	SWS
1	-1 - -0.819608	12043	1816	978	1564	16401	73.428	11.072	5.9631	9.536	76.64167	1
2	-0.819608 - -0.6	10386	2002	1234	4290	17912	57.983	11.177	6.8892	23.95	151.5967	6
3	-0.6 - -0.403922	9905	1777	1975	5397	19054	51.984	9.3261	10.365	28.325	182.0458	7
4	-0.403922 - -0.215686	8354	1946	2977	5625	18902	44.196	10.295	15.75	29.759	206.338	9
5	-0.215686 - -0.019608	5778	2160	3424	4463	15825	36.512	13.649	21.637	28.202	219.5703	10
6	-0.019608 - 0.2	3540	2127	2348	2578	10593	33.418	20.079	22.166	24.337	208.2602	9
7	0.2 - 0.45098	2098	1327	1051	2002	6478	32.387	20.485	16.224	30.905	223.6801	10
8	0.45098 - 0.741176	1537	1234	415	1110	4296	35.777	28.724	9.6601	25.838	186.8948	8
9	0.741176 - 1	1883	950	535	792	4160	45.264	22.837	12.861	19.038	156.6106	6

min	76.64167	1
max	223.6801	10
slope	0.061208	
intercept	-3.69112	

Table 5. Results of spatial analysis regarding the northness

		Sum of ghost gear impact level				Total Sum	% of ghost gear impact level				weighted score	Sum of Weighted Scores
variable category	Northness classes	value_0	value_1	value_3	value_5	sum	value_0	value_1	value_3	value_5	WS	SWS
1	-1 - -0.913725	18846	7222	9544	14361	49973	37.712	14.452	19.098	28.738	215.4343	10
2	-0.913725 - -0.772549	12171	3047	2477	7090	24785	49.106	12.294	9.9939	28.606	185.3056	8
3	-0.772549 - -0.6	7977	1967	1001	3619	14564	54.772	13.506	6.8731	24.849	158.37	6
4	-0.6 - -0.396078	5681	1205	502	1343	8731	65.067	13.801	5.7496	15.382	107.9601	3
5	-0.396078 - -0.160784	3939	699	422	508	5568	70.744	12.554	7.579	9.1236	80.90876	1
6	-0.160784 - 0.113725	2615	406	281	307	3609	72.458	11.25	7.7861	8.5065	77.14048	1
7	0.113725 - 0.419608	1650	267	203	234	2354	70.093	11.342	8.6236	9.9405	86.91589	2
8	0.419608 - 0.741176	1213	252	191	139	1795	67.577	14.039	10.641	7.7437	84.67967	1
9	0.741176 - 1	1432	274	316	220	2242	63.872	12.221	14.095	9.8127	103.5682	3

min	77.14048	1
max	215.4343	10
slope	0.065079	
intercept	-4.02021	

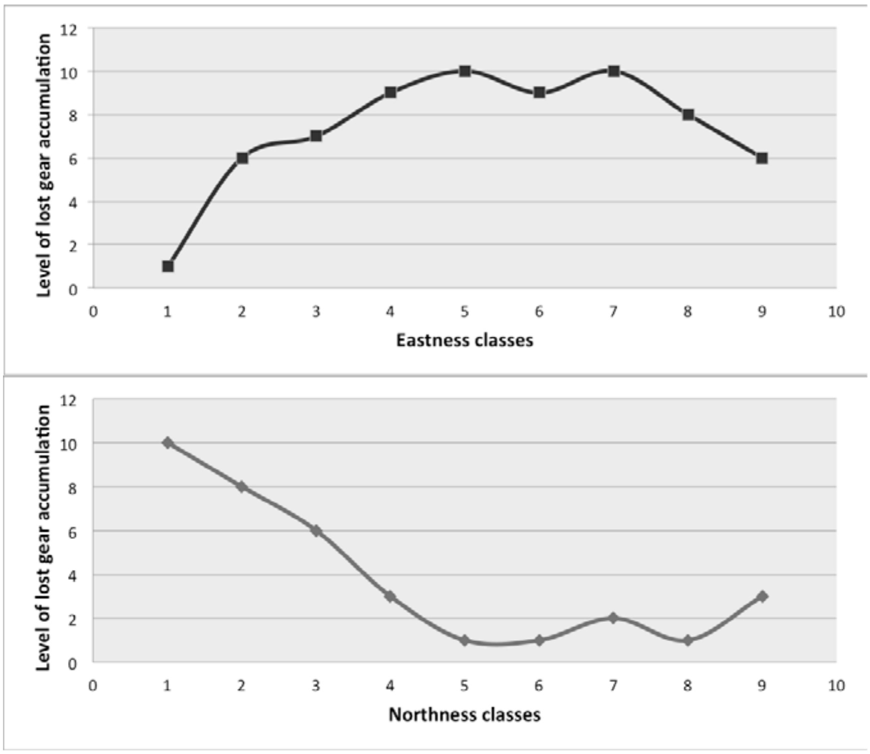

Fig. 5. Variation of eastness and northness variables with accumulation of lost fishing gear

4.4 Slope and Slopeness (slope over slope)

The most susceptible areas are characterized by low and moderate slope values (Table 6). From 0 to 5 degrees that characterize flat areas, it seems that there is very low to no LFG. At greater values of slope there is a positive relation with impact (Fig. 6). Maximum probability for the presence of abandoned gear is when slope reaches 17 and 34 degrees. However, if slope becomes too high (critical value = 34 degrees) characterizing very steep areas, we notice that the impact of LGI is decreasing. This indicates that after the critical point of 34 degrees the sea bottom morphology reaches a steep enough slope that gravity acting on the weight of the gear becomes the strongest factor pulling the gear down slope. Slopeness (Table 7) indicates that areas of low or moderate changes of slope are more susceptible to LFG accumulation. Maximum values are noted from 0-46 degrees and progressively the accumulation decreases as the slope over slope declines, which is in accordance with the above conclusion regarding weight of gear as a dominant factor when slope is too steep.

Table 6. Results of spatial analysis regarding the slope

		Sum of ghost gear impact level				Total Sum	% of ghost gear impact level				weighted score	Sum of Weighted Scores
variable category	Slope classes	value_0	value_1	value_3	value_5	sum	value_0	value_1	value_3	value_5	WS	SWS
1	0.0666 - 5	915	121	115	104	1255	72.908	9.6414	9.1633	8.2869	78.56574	1
2	5 - 17.165498	13615	4683	2394	5108	25800	52.771	18.151	9.2791	19.798	144.9806	6
3	17.165498 - 22.865131	10572	2945	2014	7316	22847	46.273	12.89	8.8152	32.022	199.4441	10
4	22.865131 - 30	12125	2476	3336	8000	25937	46.748	9.5462	12.862	30.844	202.3519	10
5	30 - 34.264396	5713	1381	2394	2728	12216	46.767	11.305	19.597	22.331	181.7534	9
6	34.264396 - 40.533992	5697	1331	2028	2101	11157	51.062	11.93	18.177	18.831	160.6167	7
7	40.533992 - 45	2736	787	922	1008	5453	50.174	14.432	16.908	18.485	157.583	7
8	45 - 55.923	3265	1266	1134	1284	6949	46.985	18.218	16.319	18.477	159.5625	7
9	55.923 - 72.736916	886	349	600	172	2007	44.145	17.389	29.895	8.57	149.9253	6

min	78.56574	1
max	202.3519	10
slope	0.072706	
intercept	-4.7122	

Table 7. Results of spatial analysis regarding the slope over slope

		Sum of ghost gear impact level				Total Sum	% of ghost gear impact level				weighted score	Sum of Weighted Scores
variable category	Slope of slope classes	value_0	value_1	value_3	value_5	sum	value_0	value_1	value_3	value_5	WS	SWS
1	0.350694 - 16.473212	736	204	514	1354	2808	26.211	7.265	18.305	48.219	303.2764	10
2	16.473212 - 27.107213	1289	340	879	2358	4866	26.49	6.9873	18.064	48.459	303.4731	10
3	27.107213 - 36.712117	1786	534	1136	2773	6229	28.672	8.5728	18.237	44.518	285.8725	9
4	36.712117 - 45.973989	2607	792	1409	3091	7899	33.004	10.027	17.838	39.132	259.1974	8
5	45.973989 - 54.892829	3672	1248	1603	2953	9476	38.751	13.17	16.916	31.163	219.7341	6
6	54.892829 - 63.468636	5415	1724	1664	2905	11708	46.25	14.725	14.213	24.812	181.423	4
7	63.468636 - 71.701411	8484	2571	1979	3092	16126	52.611	15.943	12.272	19.174	148.6295	2
8	71.701411 - 79.248122	13561	3310	2567	4275	23713	57.188	13.959	10.825	18.028	136.5749	1
9	79.248122 - 87.823929	16818	4311	2890	5020	29039	57.915	14.846	9.9521	17.287	131.1374	1

min	131.1374	1
max	303.4731	10
slope	0.052224	
intercept	-5.84848	

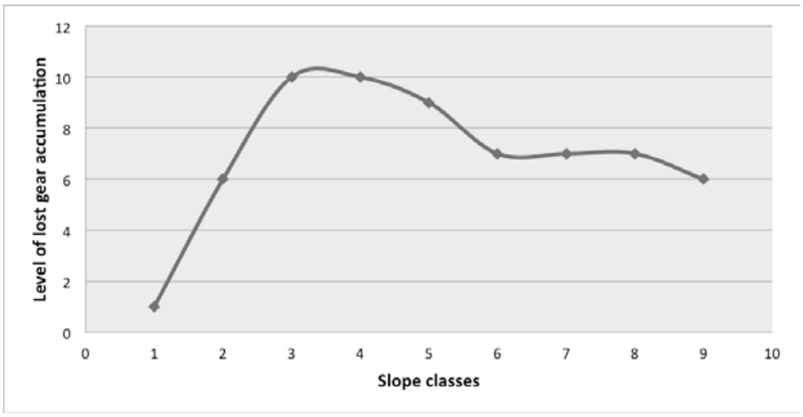

Fig. 6. Variation of slope and slopeness (slope of slope) variables with accumulation of lost fishing gear

4.5 Rugosity and roughness

Rugosity and roughness (Tables 8 and 9 respectively) show a different pattern compared to the other variables. High values of rugosity (2.6-3.3) indicated highest LFG abundance. However, low and moderate abundance of LFG was also noted in less rough areas where rugosity is low (1-1.3). This could probably signify that the nets, once they touch the sea floor, due to their weight could be difficult to be carried away from currents even in almost flat areas (Fig. 7). The same pattern is followed by roughness. Maximum accumulation of LFG is located at areas of very high roughness (mainly rocky substrate) as expected, or of very low values (0 -0.01) (flat areas). At moderate roughness the LFG abundance is generally low.

Table 8. Results of spatial analysis regarding the rugosity

		Sum of ghost gear impact level				Total Sum	% of ghost gear impact level				weighted score	Sum of Weighted Scores
variable category	Rugosity classes	value_0	value_1	value_3	value_5	sum	value_0	value_1	value_3	value_5	WS	SWS
1	1.000363 - 1.083998	20042	6598	3953	11198	41791	47.958	15.788	9.459	26.795	178.1412	5
2	1.083998 - 1.186219	18102	3771	4868	10558	37299	48.532	10.11	13.051	28.306	190.796	6
3	1.186219 - 1.307025	8468	1904	2918	3297	16587	51.052	11.479	17.592	19.877	163.6402	4
4	1.307025 - 1.45571	4160	1237	1393	1509	8299	50.127	14.905	16.785	18.183	156.1754	3
5	1.45571 - 1.632273	1922	793	656	779	4150	46.313	19.108	15.807	18.771	160.3855	3
6	1.632273 - 1.8553	977	444	300	371	2092	46.702	21.224	14.34	17.734	152.9159	2
7	1.8553 - 2.161962	482	214	250	96	1042	46.257	20.537	23.992	9.2131	138.5797	1
8	2.161962 - 2.663773	179	64	207	13	463	38.661	13.823	44.708	2.8078	161.987	3
9	2.663773 - 3.370025	25	0	80	0	105	23.81	0	76.19	0	228.5714	10

min	138.5797	1
max	228.5714	10
slope	0.100009	
intercept	-12.8592	

Chapter III

Spatial allocation of fishing activity on coralligenous habitats in Portofino MPA (Liguria, Italy)

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Abstract

Small scale and recreational fisheries monitoring and management an important challenge that coastal MPAs have to encounter, from a socio-economical, cultural and ecological point of view. The difficulty in monitoring these activities is mainly due to the fact that on the one hand, small-scale fishing shows strong heterogeneity combining different gears and targeting species throughout the year, whilst on the other hand, there is a great number of recreational fishers with several access points by boat or by shore to fish, using a variety of tools that can be adjusted depending on the practice. Understanding the spatial and temporal patterns of fishing effort is fundamental for making informed management decisions for sound conservation of benthic ecosystems and sustainable exploitation of fish stocks. The present study provides a step-by-step approach for monitoring and mapping spatial and temporal patterns of artisanal and recreational fishing activity. Simple spatial indicators and analysis are suggested in order to describe fishing pressure and identify areas that receive the greatest fishing effort, using as an example Portofino MPA (Ligurian sea, Italy). The approach integrates information originating from a range of monitoring strategies that may be adopted depending on the capacity of MPA management performance, and incorporates uncertainty regarding available information following the precautionary principle. In addition, prerequisite information such as bathymetry and distribution of habitats, and combination of monitoring strategies is suggested for increasing the confidence on spatial allocation of fishing activity. Produced results may provide baseline information for the identification of fishing metiérs, ecological modelling, stock assessments and conservation planning.

Key-words

Coralligenous habitats; spatial analysis; fishing effort; resource management; Marine Protected Area

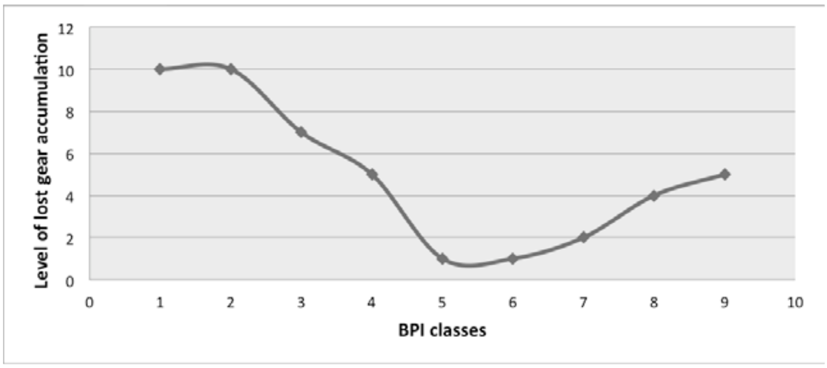

Fig. 8. Variation of BPI with accumulation of lost fishing gear

4.7 Map of susceptibility of seafloor to lost fishing gear

Based on the spatial analysis described above, a geo-referenced map of Portofino MPA was constructed in order to make informed management responses and efficient monitoring by indicating areas more susceptible to LFG (Fig. 9).

Although there is no data available information to be integrated with the oceanographic currents of the area, as shown in Fig. 10, the south eastern part of the Portofino promontory is more susceptible to accumulation of LFG in comparison to the western side, in agreement our outcomes (northness). The overlaying of the LFG with fishing effort layer showed that absolute match indicating that the accumulation of LFG is not only a matter of sea bottom and habitat complexity, but depends also from the amount of gears that potentially may be lost (Fig. 11).

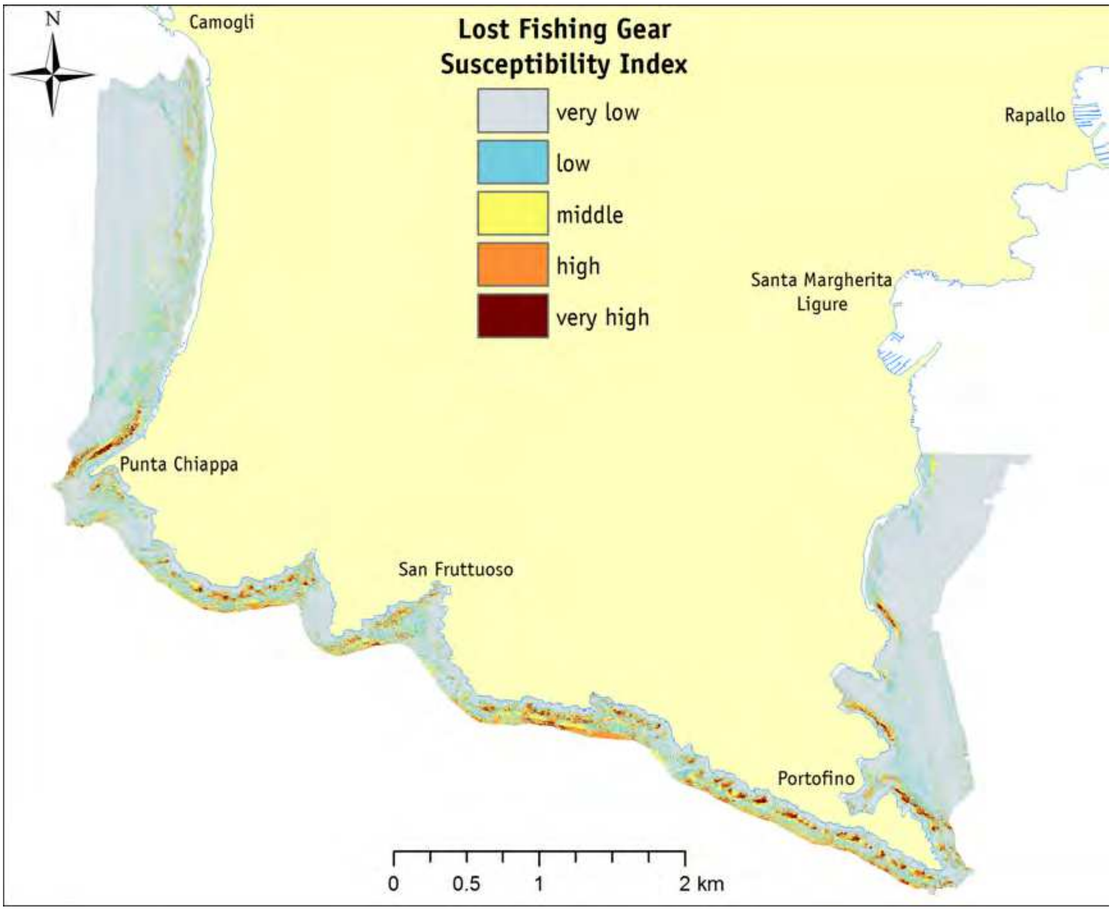

Fig. 9 Susceptibility of lost fishing gear in the Portofino MPA as predicted by the spatial analysis

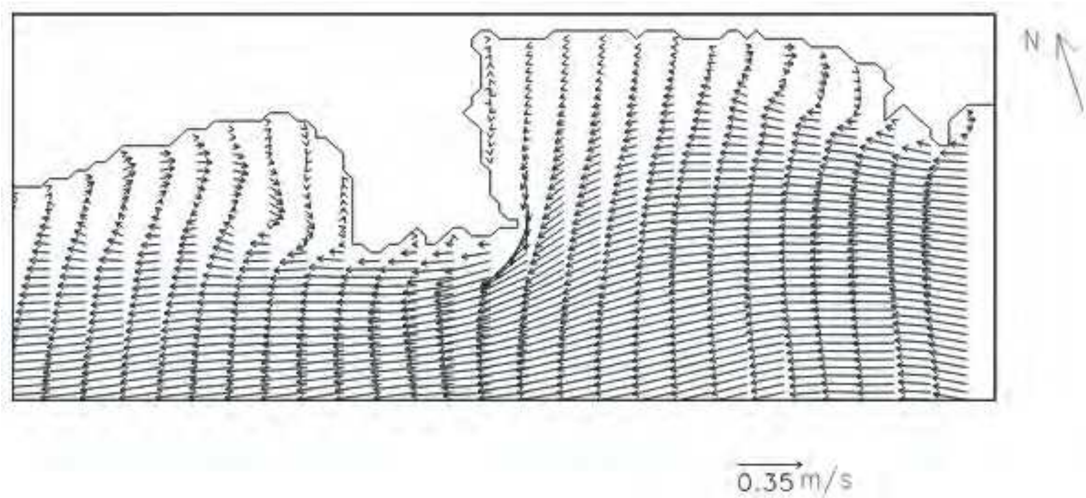

Fig 10. 3-d model of water currents in the area surrounding the Portofino MPA (Doglioli et al., 2004).

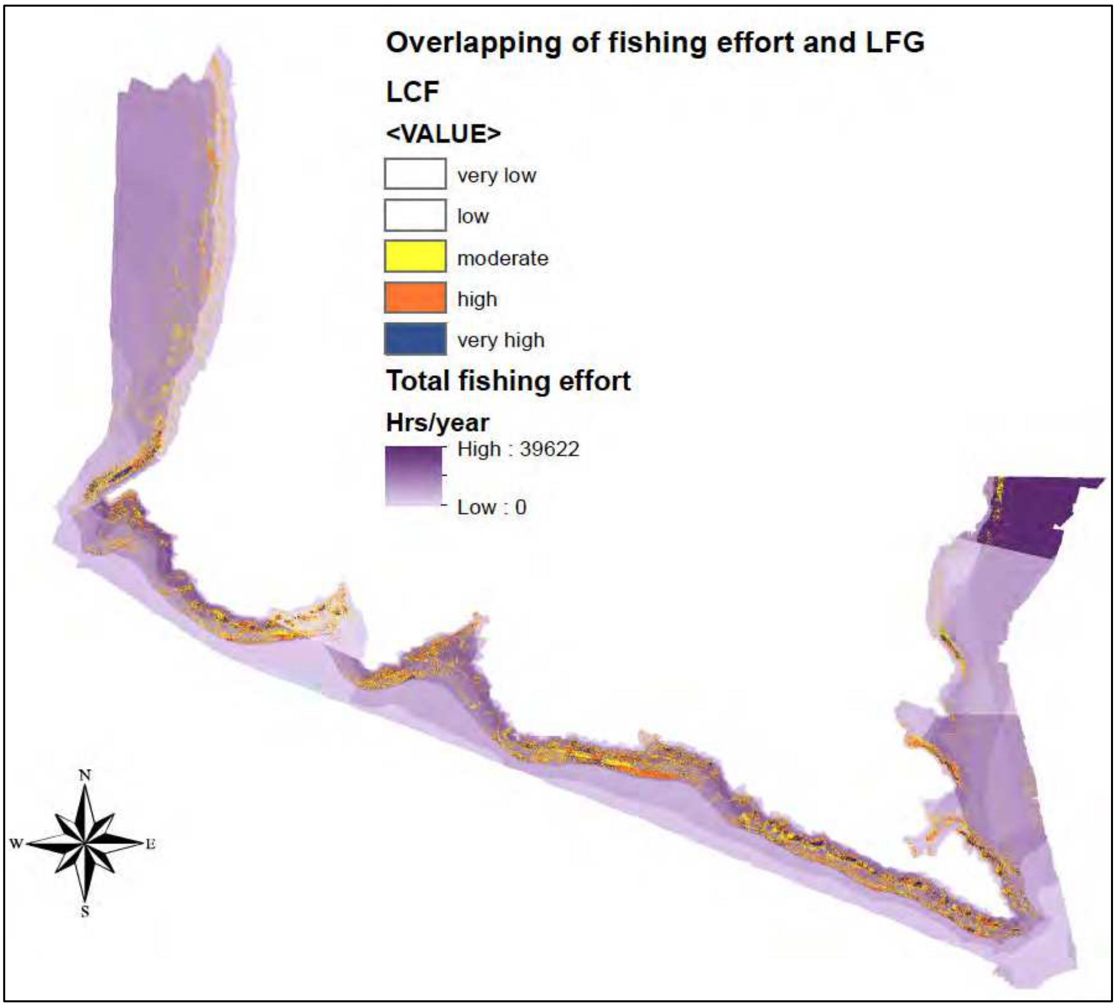

Fig 11. Overlapping of LFG susceptibility map with total fishing effort in the Portofino MPA. Low and very low susceptibility of areas are transparent in order to highlight areas of high accumulation of LFG.

5. Discussion

Lost fishing gear (LFG) in the marine environment threatens the ecological, economic and the aesthetic value of an area (UNEP, 2009). Identifying areas that are more vulnerable to LFG accumulation is a key issue in MPAs that may assist in monitoring and their direct retrieval from the sea bottom. Areas characterized by certain geomorphological features and high fishing effort facilitate the accumulation of more litter in comparison to other places (Galgani et al., 2000; Wei et al., 2012; Ramirez-Llodra et al., 2013; Pham et al., 2014). We have used spatial analysis in order to locate the areas that are more susceptible to LFG in the Portofino MPA using a wide range of components that describe the sea bottom and habitat complexity. This is a semi-quantitative method of analysis that provides essential information for MPA monitoring and retrieval of impacting LFG on benthic habitats and key habitat species. Results just correspond to when the LFG is one the seabed and not when they might be drifting in the water column. This approach yields realistic estimates without the development of an empirical model, which requires resources, skills, time and data far beyond the general possibilities of MPA authorities.

The produced map identifies that deeper areas and more distant from coast are more susceptible to LGF. Other studies in coastal areas have suggested correlation of marine litter with distance from coast, which was linked to human activities (Barnes et al., 2009; Pham et al., 2014). In our case, as show by the Fig. 4, the high fishing activity in shallower areas that overlaps with the depth and distance from coast identified in the analysis, verifies these outcomes. Moreover, the south east orientation of rocks seem to be more exposed to LFG probably due to their exposure to the water currents. Previous studies have shown that diverse geo-morphological features and hydrodynamic conditions characterize the Promontory of Portofino with a seasonal cycle related to the seasonal variations of atmospheric forcing (e.g. Britten et al., 2014; Cattaneo-Vietti et al., 2015; Doglioli et al., 2004). For instance, Doglioli et al. (2004) described the presence of a resolved bottom Ekman layer introducing a vertical shear in the incoming current, particularly noticeable in the region of the shelf break. This layer is likely to be responsible for a ‘secondary circulation’ (dominated by Coriolis effect) inducing an inshore surface current and associated upwelling in the lee of the cape and causing the observed eddy intensification.

High accumulation of lost fishing gear as revealed from the analysis takes place on quite steep slopes (17-34 degrees). However if slope is too steep such as in vertical walls, gravity becomes the dominant factor acting on the gears to pull them down the sea bottom. This can also explain partially the response of curvature that indicated more flat areas to accrue gears with preference more in concave areas rather than convex areas. High marine litter loads in areas of negative curvature has also been shown in other studies (Wei et al., 2012; Ramirez- Llodra et al., 2013; Pham et al., 2014). This could be related to gravity accumulating gear in depressions, or pits. The Benthic Position Index showed high susceptibility in areas characterized by depressions, pits, and outcrops, rather than flat terrain.

Increased susceptibility of the sea bottom to LFG is known to be related with high rugosity areas (Schlining et al., 2013). Highly rugged areas that signify “bumpiness” in the terrain seem to be at higher risk of accumulating higher quantities of LFG. These areas are of particular ecological interest as they represent important benthic habitats with protected epibenthic species present, such as corals and coralligenous, and are often associated with areas of high biodiversity (Giusti et al., 2014). The obstruction of the water flow and the creation of prolonged anoxic areas can cause substantial mortalities to sensitive species (Cerrano et al., 2014; 2000; Huete-Stauffer et al., 2011; Macfadyen et al., 2009; Vezzulli et al., 2013). LFG may cover areas or entangle branched organisms when originally dropped of and drifting on the sea floor (Brown and Macfadyen, 2007), causing abrasion and progressive removal of tissues and severe damage to sessile and long-lived organisms of structural complexity, such as gorgonians and sponges (Bavestrello et al., 1997; Cerrano et al., 2000; Fabri et al., 2014; Gori et al., 2011). In some incidents that accumulation was also noticed in flatter areas, it is possible that the gravity, the local gyres and currents could be the main factors for the final location of LFG.

Annex V of MARPOL prohibits the disposal of plastics anywhere into the sea, specifically mentioning synthetic fishing nets from ships but although this prohibition includes large areas in the Mediterranean and elsewhere, enforcement and compliance is a major challenge/obstacle along with proper education. There are currently very few legal tools that aim to control the discarding of fishing gears in the Mediterranean. ICCAT’s banning of driftnets for large pelagic species (ICCAT, 2003; GFCM, 2005) and compulsory attachment of driftnets > 2.5 km and nets >1 km to the boat outside the 12 nm limit from coast and detached but under constant observation within the 12 nm limit (GFCM, 1997). However, these regulations correspond to mainly large professional fishing, with boats >15 m length and do not secure responsibility and effectiveness in avoiding incidents of lost gears. Therefore it is strongly suggested to enforce of fishing gear marking (labeling with an owner name), and education of fishermen in order to notify cases of gear loss. Labeling may ensure that incidents of LFG will be reported rapidly and appropriate deposition of the gear will take place preventing further impact on benthoc organisms. Port reception facilities for old fishing gear may also help to reduce the incidence of lost gears on the seabed and provide data on location and type (Gilman et al., 2015). A major effort is put in a EU pilot action building working solutions and awareness among fishers and other stakeholders of all the countries surrounding the Adriatic Sea (DeFISHGear project).

No data on hydrodynamics and local currents was available, however the use of northness and eastness variables seem to correspond well on this aspect, indicating areas that are more exposed to specific direction currents. Other parameters that are considered good predictors of the presence of litter, such as the type and weight of gears observed we also absent from our dataset. The lack of USBL cables for recording of the LFG coordinates and the limited surveyed area on each geomorphic feature also prohibits accurate information collection. Limited efficient collection and monitoring information regarding those issues is a common issue, as most MPAs mainly focus their efforts on removing the gears from the sea bottom rather than monitoring. Retrieval of LFG usually involves specially trained volunteer divers and therefore the operation is highly dependent on their willingness/availability to participate. Moreover, the fact that LFG is irregularly reported to MPA management boards by users and are not easy to locate is another difficulty. Collection of large fishing nets sometimes including more than one net (e.g. trammel nets) in addition to the fouling that adds weight to the gears makes the operation difficult. Finally the abundance, density and composition of the LFG as shown in this study appears to be strongly influenced by local small scale fishing activities, which can be a useful predictor of lost fishing gear density where ground- truthed data is sparse (Spengler and Costa, 2008). Including this type of information in the analysis is expected to better inform the analysis and efficiently drive decisions regarding lost and abandoned fishing gear.

The present study has provided a guideline for identifying areas that are susceptible to LFG considering sea bottom morphology and fishing effort as driving factors. Resultant maps provide geo-referenced information that may assist MPA managers to easily monitor and manage these areas in order to avoid long-term impacts on vulnerable habitats and the sea bottom. By utilizing volunteer divers and sending them directly to those identified points, it is expected to secure a more cost-effective method to monitor and retrieve gears. From the lessons learned, successful management response is a tuned effort involving a combination of parameters that should be in agreement in order to achieve conservation goals (McLeod et al., 2009).

Therefore surveillance, marking of fishing nets, enforcement of existing laws and direct reporting of LFG, awareness and social responsibility should all be developed in parallel in order to facilitate conservation objectives and ensure healthy marine ecosystems.

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References

Angiolillo, M., Lorenzo, B.D., Farcomeni, A., Bo, M., Bavestrello, G., Santangelo, G., Cau, A., Mastascusa, V., Cau, A., Sacco, F., Canese, S., 2015. Distribution and assessment of marine debris in the deep Tyrrhenian Sea (NW Mediterranean Sea, Italy). Mar. Pollut. Bull. 92, 149–159. doi:10.1016/j.marpolbul.2014.12.044

Antonelis, K., Huppert, D., Velasquez, D., 2011. Dungeness crab mortality due to lost traps and a cost–benefit analysis of trap removal in Washington State waters of the Salish Sea. North American Journal of Fisheries Management 31, 880–893. doi:10.1080/02755947.2011.590113

Ayaz, A., Ünal, V., Acarli, D., Altinagac, U., 2010. Fishing gear losses in the Gökova Special Environmental Protection Area (SEPA), eastern Mediterranean, Turkey. Journal of Applied Ichthyology 26, 416–419. doi:10.1111/j.1439-0426.2009.01386.x

Barnes, D.K.A., Galgani, F., Thompson, R.C., Barlaz, M., 2009. Accumulation and fragmentation of plastic debris in global environments. Philosophical Transactions of the Royal Society B: Biological Sciences 364, 1985–1998. doi:10.1098/rstb.2008.0205

Bavestrello, G., Cerrano, C., ZANZI, D., Cattaneo-Vietti, R., 1997. Damage by fishing activities to the Gorgonian coral Paramuricea clavata in the Ligurian Sea. Aquatic Conserv: Mar. Freshw. Ecosyst. 7, 253–262. doi:10.1002/(SICI)1099-0755(199709)7:3<253::AID-AQC243>3.0.CO;2-1

Bergmann, M., Klages, M., 2012. Increase of litter at the Arctic deep-sea observatory Hausgarten. Mar. Pollut. Bull. 64, 2734–2741. doi:10.1016/j.marpolbul.2012.09.018

Bo, M., Bava, S., Canese, S., Angiolillo, M., Cattaneo-Vietti, R., Bavestrello, G., 2014. Fishing impact on deep Mediterranean rocky habitats as revealed by ROV investigation. Biological Conservation 171, 167–176. doi:10.1016/j.biocon.2014.01.011

Britten, G.L., Dowd, M., Minto, C., Ferretti, F., Boero, F., Lotze, H.K., 2014. Predator decline leads to decreased stability in a coastal fish community. Ecology Letters 17, 1518–1525. doi:10.1111/ele.12354

Brown, J., Macfadyen, G., 2007. Ghost fishing in European waters: Impacts and management responses. Marine Policy 31, 488–504. doi:10.1016/j.marpol.2006.10.007

Cattaneo-Vietti, R., Cappanera, V., Castellano, M., Povero, P., 2015. Yield and catch changes in a Mediterranean small tuna trap: a warming change effect? Mar Ecol 36, 155–166. doi:10.1111/maec.12127

Cerrano, C., Bavestrello, G., Bianchi, C.N., Cattaneo-vietti, R., Bava, S., Morganti, C., Morri, C., Picco, P., Sara, G., Schiaparelli, S., Siccardi, A., Sponga, F.,

2000. A catastrophic mass-mortality episode of gorgonians and other organisms in the Ligurian Sea (North-western Mediterranean), summer 1999. Ecology Letters 3, 284–293. doi:10.1046/j.1461-0248.2000.00152.x

Cerrano, C., Bertolotto, R., Coppo, S., Palma, M., Pantaleo, U., Valisano, L., Bavestrello, G., Ponti, M., 2014. Assessment of coralligenous assemblages status in the Liguria sea, in: Bouafif, C., Langar, H., Ouerghi, A. (Eds.). Presented at the UNEP/MAP- RAC/SPA, 2nd Mediterranean Symposium on the conservation of Coralligenous other Calcareous Bio-Concretions, Portorož, Slovenia, 29-30 October 2014, pp. 61–65.

Cho, D.O., 2009. The incentive program for fishermen to collect marine debris in Korea. Mar. Pollut. Bull. 58, 415–417. doi:10.1016/j.marpolbul.2008.10.004

Clark, M.R., Koslow, J.A., 2007. Impacts of Fisheries on Seamounts. Blackwell Publishing Ltd, Oxford, UK. doi:10.1002/9780470691953.ch19

Derraik, J.G.B., 2002. The pollution of the marine environment by plastic debris: a review. Mar. Pollut. Bull. 44, 842–852.

Doglioli, A.M., Griffa, A., Magaldi, M.G., 2004. Numerical study of a coastal current on a steep slope in presence of a cape: The case of the Promontorio di Portofino. Journal of Geophysical Research 109, C12033. doi:10.1029/2004jc002422

Donohue, M.J., Boland, R.C., Sramek, C.M., Antonelis, G.A., 2001. Derelict fishing gear in the northwestern Hawaiian Islands: diving surveys and debris removal in 1999 confirm threat to coral reef ecosystems. Mar. Pollut. Bull. 42, 1301–1312.

EEA, 2014. Litter in our seas. EEA signals 2015, European Environmental Agency, Copenhagen. Retrieved (08.11.2015) http://www.eea.europa.eu/signals/signals-2015/full-report

Fabri, M.C., Pedel, L., Beuck, L., Galgani, F., 2014. Megafauna of vulnerable marine ecosystems in French mediterranean submarine canyons: Spatial distribution and anthropogenic impacts. Deep Sea Research Part II: Topical Studies in Oceanography 104, 184–207. doi:10.1016/j.dsr2.2013.06.016

FAO, 2010. The State of World Fisheries and Aquaculture, 2010. Food & Agriculture Org.

Gage, JD, Roberts, JM, Hartley, JP & Humphery, JD 2005, 'Potential impacts of deep-sea trawling on the benthic ecosystem along the Northern European continental margin: a review'. in PW Barnes & JP Thomas (eds), *Benthic Habitats and the Effects of Fishing.* American Fisheries Society Symposium, vol. 41, American Fisheries Society, pp. 503-517, Symposium on Effects of Fishing Activities on Benthic Habitats, Tampa, Florida, United States, 12-14 November.

Galgani, F., Souplet, A., Cadiou, Y., 1996. Accumulation of debris on the deep sea floor off the French Mediterranean coast, Marine Ecology Progress Series. Marine Ecology Progress Series. doi:10.3354/meps142225

Galgani, F., Leaute, J.P., Moguedet, P., Souplet, A., Verin, Y., Carpentier, A., Goraguer, H., Latrouite, D., Andral, B., Cadiou, Y., Mahe, J.C., Poulard, J.C., Nerisson, P., 2000. Litter on the Sea Floor Along European Coasts. Mar. Pollut. Bull. 40, 516–527. doi:10.1016/s0025-326x(99)00234-9

GFCM, 2005. Recommendation GFCM/2005/3 Concerning Selected ICCAT Recommendations. GFCM/2005/3(A). Recommendation [03-04] by ICCAT Relating to Mediterranean Swordfish. Available online, ftp://ftp.fao.org/FI/DOCUMENT/gfcm/web/GFCM_Recommendations2005.pdf, General Fisheries Commission for the Mediterranean, Rome (accessed 10.10.14).

GFCM, 1997. Limitation of the Use of Driftnets in the Mediterranean. REC.CM-GFCM/22/1997/1, General Fisheries Commission for the Mediterranean, Rome, 1997.

Gilardi, K.V.K., Carlson-Bremer, D., June, J.A., Antonelis, K., Broadhurst, G., Cowan, T., 2010. Marine species mortality in derelict fishing nets in Puget Sound, WA and the cost/benefits of derelict net removal. Mar. Pollut. Bull. 60, 376–382.

doi:10.1016/j.marpolbul.2009.10.016

Gilman, E., 2015. Status of international monitoring and management of abandoned, lost and discarded fishing gear and ghost fishing. Marine Policy 60, 225–239. doi:10.1016/j.marpol.2015.06.016

Giusti, M., Innocenti, C., Canese, S., 2014. Predicting suitable habitat for the gold coral *Savalia savaglia* (Bertoloni, 1819) (Cnidaria, Zoantharia) in the South Tyrrhenian Sea. Continental Shelf Research 81, 19–28. doi:10.1016/j.csr.2014.03.011

Good, T.P., June, J.A., Etnier, M.A., Broadhurst, G., 2010. Derelict fishing nets in Puget Sound and the Northwest Straits: patterns and threats to marine fauna. Mar. Pollut. Bull. 60, 39–50. doi:10.1016/j.marpolbul.2009.09.005

Gori, A., Rossi, S., Berganzo, E., Pretus, J.L., Dale, M.R.T., Gili, J.-M., 2011. Spatial distribution patterns of the gorgonians *Eunicella singularis, Paramuricea clavata, and Leptogorgia sarmentosa* (Cape of Creus, Northwestern Mediterranean Sea). Marine Biology 158, 143–158. doi:10.1007/s00227-010-1548-8

Grieve, C., Brady, D.C., Polet, H., 2014. Best practices for managing, measuring and mitigating the benthic impacts of fishing. Marine Stewardship Council Science Series 2, 18–88.

Gunn, R., Hardesty, B.D., Butler, J., 2010. Tackling "ghost nets": Local solutions to a global issue in northern Australia. Ecological Management & Restoration 11, 88–98. doi:10.1111/j.1442-8903.2010.00525.x

Heifetz, J., Stone, R.P., Shotwell, S.K., 2009. Damage and disturbance to coral and sponge habitat of the Aleutian Archipelago. Mar. Ecol. Prog. Ser. 397, 295–303. doi:10.3354/meps08304

Huete-Stauffer, C., Vielmini, I., Palma, M., Navone, A., Panzalis, P., Vezzulli, L., Misic, C., Cerrano, C., 2011. *Paramuricea clavata* (Anthozoa, Octocorallia) loss in the Marine Protected Area of Tavolara (Sardinia, Italy) due to a mass mortality event. Mar Ecol 32, 107–116. doi:10.1111/j.1439-0485.2011.00429.x

ICCAT, 2003. Recommendation by ICCAT Relating to Mediterranean Swordfish, International Commission for the Conservation of Atlantic Tunas, Madrid, Spain, 2003, Recommendation03-04.

Imamura, J., 2011. ENFO reports at the annual meeting on enforcement activities. News lett. North Pacific Anadromous Fish Comm 29, 3.

Kaiser, M.J., Collie, J.S., Hall, S.J., Jennings, S., Poiner, I.R., 2003. Impacts of fishing gear on marine benthic habitats., Responsible fisheries in the marine ecosystem. CABI, Wallingford. doi:10.1079/9780851996332.0197

Macfadyen, G., Huntington, T., Cappell, R., Food and Agriculture Organization of the United Nations, Programme, U.N.E., 2009. Abandoned, lost or otherwise discarded fishing gear. Food & Agriculture Org.

McLeod, E., Salm, R., Green, A., Almany, J., 2009. Designing marine protected area networks to address the impacts of climate change. Frontiers in Ecology and the Environment 7, 362–370. doi:10.1890/070211

Markantonatou, V., Marconi, M., Cappanera, V., Campodonico, P., Bavestrello, A., Cattaneo-Vietti, R., Papadopoulou, N., Smith, C., Cerrano, C., 2014. Spatial allocation of fishing activity on coralligenous habitats in Portofino MPA (Liguria, Italy), in: Bouafif, C., Langar, H., Ouerghi, A. (Eds.). Presented at the UNEP/MAP- RAC/SPA, Proceedings of the second Mediterranean Symposium on the conservation of Coralligenous and other Calcareous Bio-Concretions. Portorož, Slovenia, 29-30 October 2014, Portorož, Slovenia, pp. 118–123.

Matsuoka, T., Nakashima, T., Nagasawa, N., 2005. A review of ghost fishing: scientific approaches to evaluation and solutions. Fisheries Science 71, 691–702. doi:10.1111/j.1444-2906.2005.01019.x

Moore, C.J., 2008. Synthetic polymers in the marine environment: a rapidly increasing, long-term threat. Environ. Res. 108, 131–139. doi:10.1016/j.envres.2008.07.025

Mordecai, G., Tyler, P.A., Masson, D.G., Huvenne, V.A.I., 2011. Litter in submarine canyons off the west coast of Portugal. Deep Sea Research Part II: Topical Studies in Oceanography 58, 2489–2496. doi:10.1016/j.dsr2.2011.08.009

Pawson, M.G., 2003. The catching capacity of lost static fishing gears: introduction. Fisheries Research 64, 101–105. doi:10.1016/s0165-7836(03)00208-x

Pham, C.K., Stewart, H.A., 2014. Marine litter distribution and density in European Seas, from the shelves to deep basins.

Ramirez-Llodra, E., Tyler, P.A., Baker, M.C., Bergstad, O.A., Clark, M.R., Escobar, E., Levin, L.A., Menot, L., Rowden, A.A., Smith, C.R., Van Dover, C.L., 2011. Man and the last great wilderness: Human impact on the deep sea. PLoS ONE 6, e22588. doi:10.1371/journal.pone.0022588

Ramirez-Llodra, E., De Mol, B., Company, J.B., 2013. Effects of natural and anthropogenic processes in the distribution of marine litter in the deep Mediterranean Sea. Progress in Oceanography 118, 273–287. doi:10.1016/j.pocean.2013.07.027

Rodríguez, B., Bécares, J., Rodríguez, A., Arcos, J.M., 2013. Incidence of entanglements with marine debris by northern gannets (Morus bassanus) in the non-breeding grounds. Mar. Pollut. Bull. 75, 259–263. doi:10.1016/j.marpolbul.2013.07.003

Santos, M.N., Saldanha, H., Gaspar, M.B., Monteiro, C.C., 2003. Causes and rates of net loss off the Algarve (southern Portugal). Fisheries Research 64, 115–118. doi:10.1016/s0165-7836(03)00210-8

Schlining, K., Thun, von, S., Kuhnz, L., Schlining, B., 2013. Debris in the deep: Using a 22-year video annotation database to survey marine litter in Monterey Canyon, central California, USA. Deep Sea Research Part I: Oceanographic Research Papers 79, 96–105. doi:10.1016/j.dsr.2013.05.006

Spengler, A., Costa, M.F., 2008. Methods applied in studies of benthic marine debris. Mar. Pollut. Bull. 56, 226–230. doi:10.1016/j.marpolbul.2007.09.040

Tasker, M.L., Camphuysen, C.J., Cooper, J., Garthe, S., Montevecchi, W.A., Blaber, S.J.M., 2000. The impacts of fishing on marine birds. ICES J. Mar. Sci. 57, 531–547. doi:10.1006/jmsc.2000.0714

Thompson, R.C., Olsen, Y., Mitchell, R.P., Davis, A., Rowland, S.J., John, A.W.G., McGonigle, D., Russell, A.E., 2004. Lost at sea: where is all the plastic? Science 304, 838–838. doi:10.1126/science.1094559

Uhlmann, S., Fletcher, D., Moller, H., 2005. Estimating incidental takes of shearwaters in driftnet fisheries: lessons for the conservation of seabirds. BIOLOGICAL CONSERVATION 123, 151–163. doi:10.1016/j.biocon.2004.11.003

UNEP, 2009. Marine Litter: A Global Challenge. Nairobi, UNEP.

UNEP, 2005. Marine Litter: An Analytical Overview. Nairobi, UNEP.

Vanderlaan, A., Smedbol, R.K., 2011. Fishing-gear threat to right whales (Eubalaena glacialis) in Canadian waters and the risk of lethal entanglement. Canadian Journal of Fisheries and Aquatic Sciences 68, 2174–2193. doi:10.1139/f2011-124

Vezzulli, L., Pezzati, E., Huete-Stauffer, C., Pruzzo, C., Cerrano, C., 2013. 16SrDNA Pyrosequencing of the Mediterranean Gorgonian Paramuricea clavata Reveals a Link among Alterations in Bacterial Holobiont Members, Anthropogenic Influence and Disease Outbreaks. PLoS ONE 8, e67745. doi:10.1371/journal.pone.0067745

Watters, D.L., Yoklavich, M.M., Love, M.S., 2010. Assessing marine debris in deep seafloor habitats off California. Mar. Pollut. Bull. 60, 131–138. doi:10.1016/j.marpolbul.2009.08.019

Wilcox, C., Heathcote, G., Goldberg, J., Gunn, R., Peel, D., Hardesty, B.D., 2015. Understanding the sources and effects of abandoned, lost, and discarded fishing gear on marine turtles in northern Australia. Conservation Biology 29, 198–206. doi:10.1111/cobi.12355

Woodall, L.C., Robinson, L.F., Rogers, A.D., Narayanaswamy, B.E., Paterson, G.L.J., 2015. Deep-sea litter: a comparison of seamounts, banks and a ridge in the Atlantic and Indian Oceans reveals both environmental and anthropogenic factors impact accumulation and composition. Frontiers in Marine Science 2, 643. doi:10.3389/fmars.2015.00003

Zabka, T.S., Haulena, M., Puschner, B., Gulland, F.M.D., Conrad, P.A., Lowenstine, L.J., 2006. Acute Lead Toxicosis in a Harbor Seal (Phoca vitulina richardsi) Consequent to Ingestion of a Lead Fishing Sinker. Journal of Wildlife Diseases 42, 651–657. doi:10.7589/0090-3558-42.3.651

Chapter VI
Re-zoning Portofino Marine Protected Area to assist decision-making to achieve better conservation outcomes: preliminary results

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Abstract

Systematic conservation planning tools can assist in selecting areas ('zones') where ecological targets are being reached with the least possible opportunity cost for other human uses. We applied a systematic conservation approach to assist Portofino Marine Protected Area (MPA) managers (Liguria Sea, Italy) in a planning process aiming at increasing the MPA surface to achieve sounder protection of vulnerable habitats and species present. Using Marxan With Zones we generated possible scenarios for the enlargement and the re- zoning of the Portofino MPA. Preliminary results presented here suggest a 4-zoning plan that regulates and spatially allocates human activities with the least opportunity cost, reaching at the same time high conservation targets. The targets were set at various levels in accordance to the MPA's objectives and EU guidelines. The case study is of particular interest, since Portofino MPA represents the vast majority of Mediterranean MPAs, characterized by small surface area and multiple overlapping users' conflicts. The study applies innovative conservation planning tools to efficiently inform management decisions, and verifies the performance capacity of Marxan With Zones to provide flexible and low-cost zoning solutions at the local scale, as well as it performs at the larger scale.

Keywords: Conservation planning**;** Marxan with zones**;** Marine Protected Area**;** Portofino MPA

1. Introduction

The reduction of marine resources and ecosystem services worldwide (Halpern et al., 2008) has prompted the establishment of Marine Protected Areas (MPAs), in line with the Convention on Biological Diversity that has set as biodiversity target for Marine Protected Areas (MPAs) to reach 10% of our oceans by 2020. MPAs are considered valuable in preventing extinction of endangered species and the loss of vital habitats, however the socio-economic benefits they generate remain difficult to predict and are still under debate (Gell and Roberts, 2003; Hilborn et al., 2006). Many MPAs fail to reach their full conservation potential due to their small size, and their lack of or limited no-take zone that excludes important species and essential habitats for their life cycle stages from the MPA protection boundaries (Edgar et al. 2014; McLeod et al., 2009). The majority of MPAs in the Mediterranean for instance are coastal, with limited deep parts included within their borders, causing the discontinuity of habitats and unconstrained movement of fish across MPA boundaries (Abdulla et al., 2008). Although there is no ideal size for MPAs, it is well accepted that MPAs must be large enough in order to protect the suite of marine habitat types and the ecological processes and functions present within their boundaries following the MPA objectives (McLeod et al., 2009). Other reasons acknowledged for the MPAs inadequacy to achieve conservation targets are related to the 'maturity' of the MPA in terms of years of efficient management, the existence of patrolling and the law enforcement (Babcock et al., 2010; Edgar, 2011; Mora, 2006). In order for MPAs to be effective they should not be considered as isolated systems, but should be integrated into larger marine spatial plans that consider human activities, biodiversity, ecosystem services etc. in a more holistic way.

Ecosystem-based management (EBM) approaches such as Marine Spatial Planning (MSP), provide a mechanism for reaching a consensus among multi-sectoral operations and the ecosystem processes, functions, and services (Ehler and Douvere, 2009; Pomeroy and Douvere, 2008). MSP aims to derive maximized long-term ecological benefits and socio-economic welfare in an area (Clarke and Jupiter, 2010). In order for managers to reach such complex objectives a multiple conservation zoning should be planned, where compatible human activities and potential biodiversity threats are managed within specified areas or '*zones*' (Agardy, 2010; Mazor et al., 2014). During the process different potential costs and benefits to all user groups are considered, making planning more transparent and efficient, with higher likelihood to receive public support and mitigate users' conflicts (Douvere, 2008; Makino et al., 2013; Villa et al., 2002). Multiple zoning scenarios will be generated through an adaptive process to provide flexible solutions for stakeholders and support efficiently management decisions (Butt et al., 2013).

Systematic conservation planning (SCP) aims to deliver operational models that cover both design and implementation of conservation, and to suggest direct actions that will be agreed and implemented through a collective process (Kukkala and Moilanen, 2013). Portofino Marine Protected Area (MPA) established in 1999 by the Italian Ministry of the Environment is located in the Liguria Sea (fig. 1) and is the third smallest MPA in Italy (total surface 3.74km^2). The marine area surrounding the Promontory of Portofino is characterized by a particularly rich biodiversity and high geomorphological complexity. Due to the *Posidonia oceanica* meadows, underwater caves, and rocky reefs present hosting a significant number of threatened and endangered species, in 2005 Portofino MPA was declared a Specially Protected Area of Mediterranean Importance (SPAMI). The marine and terrestrial part are a Site of Community Importance (SCI) under the EU Habitats Directive (92/43/EEC), however a large portion of the SCI that includes the deep part of coralligenous, is currently outside the MPA boundaries. Portofino MPA has extreme economic importance for the local community and the surrounding areas hosting a significant amount of anthropogenic activities, such as yachting, SCUBA diving, artisanal and recreational fishing.

The MPA has a multi-zone plan defined by three zones (full protection, general protection, partial protection) within which human activities are regulated and monitored mainly through permissions and monitoring diaries. Diving is allowed to authorized operators of the wider area of the MPA with an annual fee. Professional and recreational fishing is allowed only to residents of the three institutional municipalities. Non-resident recreational fishers are allowed to fish exclusively in zone C. Several regulations including spatial closures, gear modifications and catch limitations are currently in force for fishing, while spearfishing and the catch of *Epinephelus marginatus* is strictly prohibited. The Italian law N. 394 of 1991 (Article 19) provides the possibility of establishing an experimental protection zone ('area of protection and development') in accordance with the terrestrial protected areas, which intends to regulate certain activities for the sustainable development of the MPA, taking into account the necessity of protection of the seabed.

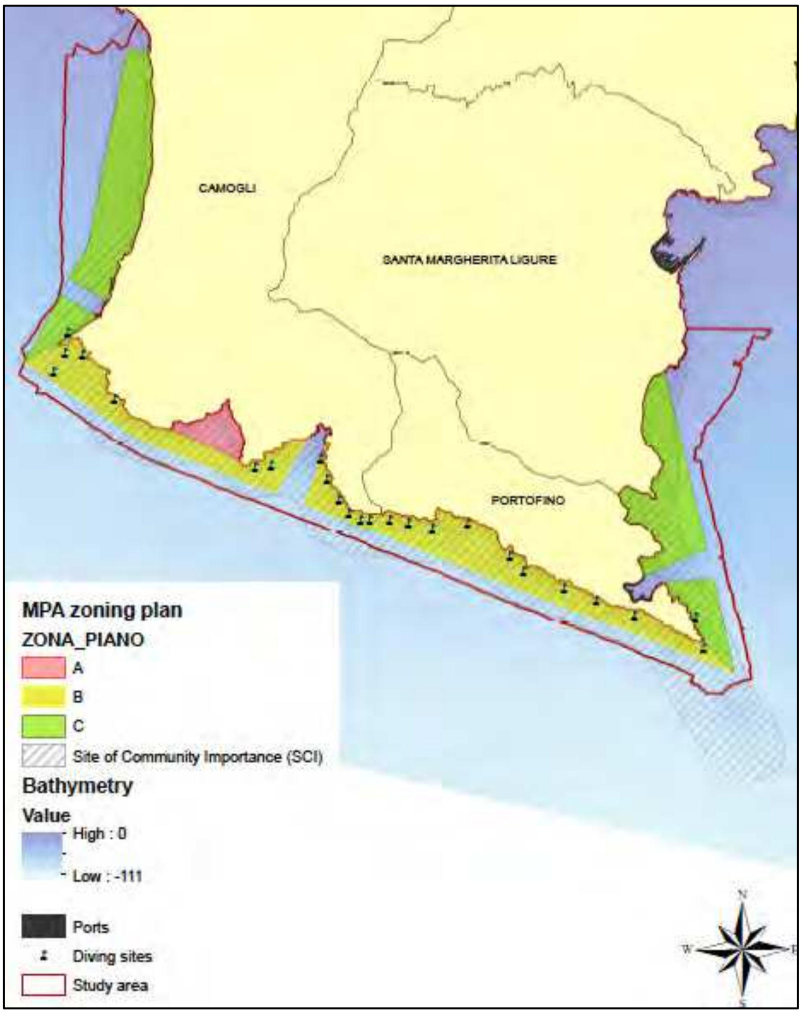

Fig. 1. Portofino MPA, the designated SCI and the study area.

Currently Portofino MPA management board is considering of initiating a planning process to expand its area towards more effective conservation of its biodiversity. As a response to the need for updated information and planning recommendations we have applied a systematic conservation approach for the development of future scenarios regarding the enlargement and re- zoning of the MPA. We present preliminary findings of one out of many scenarios to be implemented in the study area. The analysis is driven by the MPA's ecological, cultural and socio-economic objectives, and important EU Directives targeting directly on conservation. Due to the fact that in the past similar initiatives in the area have stimulated opposition from stakeholders (Salmona and Verardi, 2001), the proposed conservation plan is expected to provide a flexible and low-cost zoning solution for managers that will limit existing conflicts (Ball et al., 2009). Furthermore, the study explores the performance capacity of Marxan With Zones to facilitate managers and planners in designing robust MPAs at the local scale, as well as well as it performs at the larger scale (e.g. Giakoumi et al., 2012; 2013; Mazor et al., 2014).

2. Systematic Conservation Planning and core principles

Systematic Conservation Planning (SCP) aims at guiding conservation decision-making through an efficient, structured and transparent process (Margules and Pressey, 2000). The core principles of SCP frame the conditions under which a reserve system should be established.

The principle of connectivity, defined as the natural linkages between marine habitats (Roberts et al., 2003), suggests that the ecological connections between sites via larval dispersal or active migration- connectivity should be ensured (Wilson et al., 2009a). *Connectivity* secures that biodiversity components are replenishing and are able to recover after a disturbance event eliminating the risk of extinction (Green et al., 2007; Roberts et al., 2003). Meta-population genetics support that connectivity highly depends on the focus species and the local oceanographic conditions, but may demand short distances so that larval dispersal may be secured in space (Almany et al., 2007; Costantini et al., 2013; 2011; Cowen et al., 2006). Others suggest that the entire ecological units of benthic habitats should be included in the MPA design to secure larval dispersal and adults mobility (Salm and Coles, 2001). Mumby (2006) suggested that connectivity between different vulnerable habitats should also be considered in the planning process, due to the interconnectedness that exists between functionally linked habitats. In any case, a prerequisite for the selection of conservation areas should also incorporate the principle of *adequacy* to secure the *persistence* of the biodiversity features, in terms of long-term survival of healthy species populations and maintenance of the natural processes (Pressey et al., 2007; Soule, 1987).

Zoning plans must also secure that the selected protected area is *representative* of the full biodiversity at all ecosystem levels (Barr and Possingham, 2013; Klein et al., 2010; Mazor et al., 2014). A range of representative habitat types and communities MPAs must be selected to provide greater conservation potential of an area's biodiversity components and ecological functions (McLeod et al., 2009). This may result to the inclusion of small areas within the conservation selection in order ensure the presence of unique or rare habitats representing the diversity and heterogeneity of the region (Foley et al., 2010; Higgs, 1981; Margules and Pressey, 2000).

However, a portion of every biodiversity feature should be included in the selected priority areas in terms of composition, structure and function to assure c*omprehensiveness* of the system (Foley et al., 2010; Wilson et al., 2009a; 2009b). Considering the limited knowledge on we still have on the ecological processes and the spatial distribution of species and habitats, *comprehensiveness* promotes the inclusion of many well-known biodiversity features in order to act as surrogates and cover all possible biodiversity aspects, processes and interactions within the system that are currently unknown (Wilson et al., 2009a). One way to achieve comprehensiveness is to seek a system of *complementary* planning units that when considered together all biodiversity features have received some level of conservation investment while the conservation cost is minimized (Margules and Pressey, 2000). Furthermore, areas already receiving a conservation investment, such as existing MPAs, must be considered in the planning design (Possingham et al., 2006).

Finally, cost-effective management solutions are highly desired in order to guarantee a balance between conservation objectives and operational cost of implementation. Integration of the cost increases the efficiency of the planning process and the likelihood that conservation plans will be implemented with the least possible conflicts and oppositions from stakeholders (Wilson et al., 2009a). The operational cost may include acquisition costs, management costs, transaction costs or opportunity cost in terms of financial value (Naidoo and Adamowicz, 2006).

3. Spatial prioritization software: Marxan With Zones

Generic design criteria for the selection of priority areas can be applied to produce the desired configuration by using conservation planning software such as Marxan and Marxan with Zones Decision Support Tools (DSTs). These tools aim at guiding conservation decision-making through a repeatable, transparent and structured selection process (Margules and Pressey, 2000). Following a SCP approach they may provide direct answers even to very complex problems of an area

(Possingham et al., 2006). The conservation configuration is a solution that fully specifies the type of zone in which each planning unit is placed where specific activities are prohibited and others allowed (Makino et al., 2013). The generation of the configuration solution is based on numerical optimization for best meeting conservation goals with the minimum operational cost (Klein et al., 2010). These tools may solve complex management problems under a wide range of planning objectives and different spatial scales. For instance, Marxan has been used for the designation of MPAs and MPA networks (e.g. Agostini et al., 2010; Ban et al., 2013; Fernandes et al., 2005 Klein et al., 2008; Ruiz-Frau et al., 2015), or the exploration of conservation achieved with existing protection (e.g. Giakoumi et al., 2012; 2013). Marxan with Zones represents a shift from the basic reserve design problem and introduces zoning as a formal consideration of the conservation planning problem. Marxan With Zones allows the setting of different targets and the spatial allocation of human uses within certain zones, adding the desired flexibility to reach the overall conservation objectives and provide management solutions (e.g. Klein et al., 2010; Mazor et al., 2014). The numerical algorythm minimizes the total cost of a zoning system, which is the sum of the costs of placing each planning unit into a particular zone. In turn, each zone is subject to meeting target contribution amounts of conservation features that measures the zone effectiveness (Watts et al., 2009). Specifically, Marxan with Zones solves the mathematical problem:

$$\text{minimize} \sum_{i=1}^{m} \sum_{k=1}^{p} c_{ik} x_{ik},$$

$$\text{subject to} \sum_{i=1}^{m} \sum_{k=1}^{p} a_{ij} e_{jk} x_{ik} \geq s_j \forall j \text{ and } \sum_{i=1}^{m} \sum_{k=1}^{p} a_{ih} e_{hk} x_{ik} \geq t_h \forall h,$$

where

m is the total number of planning units (i=1,…, m)

p is the total number of zones (k=1,…, p),

c_{ik} is the cost of allocating planning unit i to zone k. For all planning units i (i=1, …, m) and zones k (k=1,…, p), x_{ik} is a member of {0, 1} and if planning unit i is allocated as zone k, x_{ik}~1 and if not x_{ik}~0. A planning unit i cannot be allocated to more than one zone, thus:

$$\sum_{k=1}^{p} x_{ik} \leq 1$$

Using simulated annealing algorithm (Kirkpatrick et al., 1983) Marxan with Zones will meet the conservation target while applying the zone effectiveness: a_{ij} is the amount of conservation feature j (j=1, …, n) in planning unit i, and e_{jk} is the zone effectiveness of zone k to conservation feature j. The target amount for conservation feature j is defined as s_j.

Finally, Marxan with Zones will select the planning units assigning a number or states or zones that will compile the conservation configuration (Watts et al., 2009).

4. Methods

4.1. Definition of spatial extend and Planning Units (PUs)

The study area (Fig.2) of 6.7 km^2 included the MPA and a large proportion of the surrounding area. The boundaries were mainly defined by the availability of data provided by the MMMPA project ensuring at the same time that the majority of all vulnerable habitats and the SCI were included in the case study.

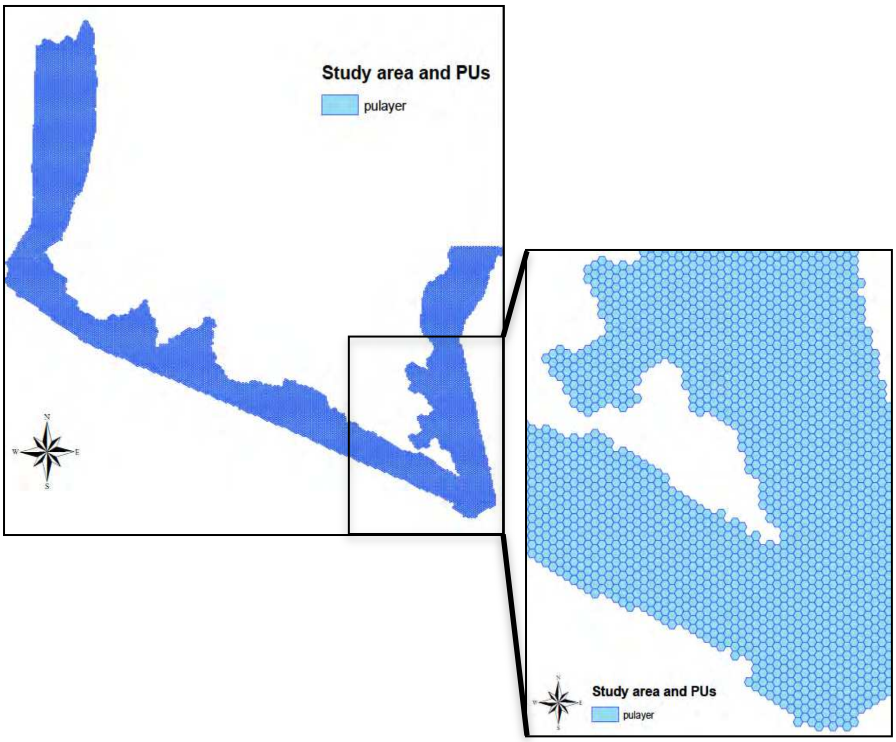

Fig. 2. The study area and Planning Units (PUs)

Planning Units (PUs) are typically discrete “placed-based” geographic locations or zones that may have particular characteristics of interest (Olsen et al., 2010). A grid of 14 221 hexagons with surface area of 500m^2 each was generated to create the PUs. This resolution was chosen as the most suitable considering the technical prerequisites of the analysis and the feasibility of management decisions. The extent of each ecological feature and socio-economic cost was calculated for each PU as explained below, in order for every PU to include all relevant information for the analysis.

4.2. Conservation features and conservation objectives

In total, 23 conservation features were collated using a variety of sources, including results produced by the WP1 (‘Biodiversity’) of MMMPA project. The conservation features included 6 habitat types, 4 fish species, 14 morpho-sedimentary features that characterize the sea bottom and the biodiversity components of the area, with special care to secure the principles of representativeness and complementarity of ecosystems. Further details on the conservation features layers may be found in the Appendix (Table 1, Fig. 1-22).

The targets for the conservation features were defined following the MPA management objectives and EU directives and guidelines (e.g., the SPAMI protocol, the Common Fisheries Policy, the Marine Strategy Framework Directive, the Habitats Directive etc.). For instance, the SPAMI protocol obliges to set strict conservation targets and reduce the pressure on the critical habitats, seabed characteristics, rare formations and the emblematic, endemic species or species in critical danger that they host (UNEP-MAP, RAC-SPA, 2010). Therefore, the objectives were divided into three categories corresponding to high, moderate and low priority conservation features (Table 1).

Table 1. Conservation objectives corresponding to the different priority levels of conservation features

Conservation feature priority	Objective % of target to sustain
High	60%
Moderate	30%
Low	10%

The first category, "high priority" included priority features according to the EU Habitats Directive (92/43/EEC), and endangered species according to IUCN (EN A2d, Annex III): the seagrass *Posidonia oceanica* meadows, coraligenous communities, brown alga *Cystoseira amentacea var. stricta* forests, and the dusky grouper *Epinephelus marginatus*. The second category, "moderate priority", included other important features of the case study area: rugosity, the brown meagre *Sciaena umbra*, caves, and overhangs. Finally, the third category included the remaining morpho-sedimentary features and some fish species that represented "low" or "very low" priority features.

Regarding the information coming from ecological predictive models such as MAXENT, we first applied a fixed logistic threshold value of 0.75. By selecting this threshold we conservatively selected environmental conditions where the feature is highly likely to be present (Allnutt et al., 2012). In general, all habitats, geomorphological and sedimentary features were described by using their spatial extend within a PU. The few exceptions were the *Posidonia oceanica* meadows and *Cystoseira amentacea var. stricta* forests for which information on their health status was available, and the slope and rugosity features for which the mean value was calculated within each PU. The distribution of fish was in presence/ absence format in each PU.

The promotion of socio-economic development of the area is amongst the MPA's institutional objectives, that suggest the enhancement of existing traditional activities and uses that are considered sustainable in accordance with conservation. Therefore, we have set targets for human use features, such as diving, small-scale fishing and 'tonarella'[1], in order to sustain an amount of these activities in the conservation solution (Ban et al., 2013). This combined analysis secured that a proportion of these human activities (80%) is included within the management plan, while provides the flexibility to minimize spatial conflicts of users, such as for instance between small-scale fishing and diving that we have aimed at a zoning that would allow only 20% of overlap between the two activities.

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[1] *'Tonarella' is a small trap formed by a barrage netplaced in the center of a complex oceanographic system that lies within the clockwise gyre in front of the town of Camogli targeting pelagic fish schools (Britten et al., 2014; Cattaneo-Vietti et al., 2015), which is currently the last remaining in the Mediterranean (Cappanera V., personal communication).*

4.3. Cost (socio-economic factors)

The ability of Marxan With Zones to specify costs in zone-specific planning units provides a number of potential uses in conservation planning (Watts et al., 2009). Three main economic activities (diving, recreational, and small-scale commercial fishing) were considered for the creation of the opportunity cost layer. The main criterion for the selection of economic activities incorporated in the opportunity cost layer, was the capacity to take action and manage more efficiently these activities. The cost for each human activity was expressed as a surrogate of the annual frequency of events within each planning unit (Appendix, Table 2, fig. 23-25).

Fishing activity was divided in three sectors: small-scale commercial fishing (bottom longlines, trammel nets, gill nets, combined nets), recreational non-destructive fishing, and recreational destructive fishing (e.g. bottom longlines, vertical jigging and bottom trolling). *'Destructiveness'* of a fishing practice was defined by its capacity to potentially cause damage to the seafloor integrity and the benthic habitats (Markantonatou et al., *in prep.*). Fishing information was mapped by integrating different sources of data, such as fishing diaries ('logbooks'), on board observers, previous monitoring projects (MARTE plus, 2011) and interviews during the period 2012-2015 as described in (Markantonatou et al., 2014). In total, 24 active artisanal fishermen and about 300 sport fishermen were mapped to characterize the fishing sector operating in the wider area of the Portofino Promontory. Diving was mapped using the number of dives per diving site using information provided by the MPA monitoring. In total 27 734 dives were recorded in 2014 in the MPA.

The total cost for each PU (Fig. 3) was calculated by summing and normalizing the information contained within a PU (Giakoumi et al., 2012; Stewart and Possingham, 2005). Hence, PUs with higher values in terms of frequency of activities were considered more important for users and therefore more costly to be included in the MPA (Makino et al., 2013).

PUs containing severely impacted or moderated (Fig. 4) due to human activities, such as ports, marinas and their access corridors, and underwater pipelines, were excluded (Giakoumi et al., 2012). Anchoring, currently taking place on parts of *Posidonia oceanica* meadows, was not included in the analysis suggesting full prohibition of this activity based on the Barcelona Convention (SPAMI Protocol) and the presence of critical habitats in the whole area.

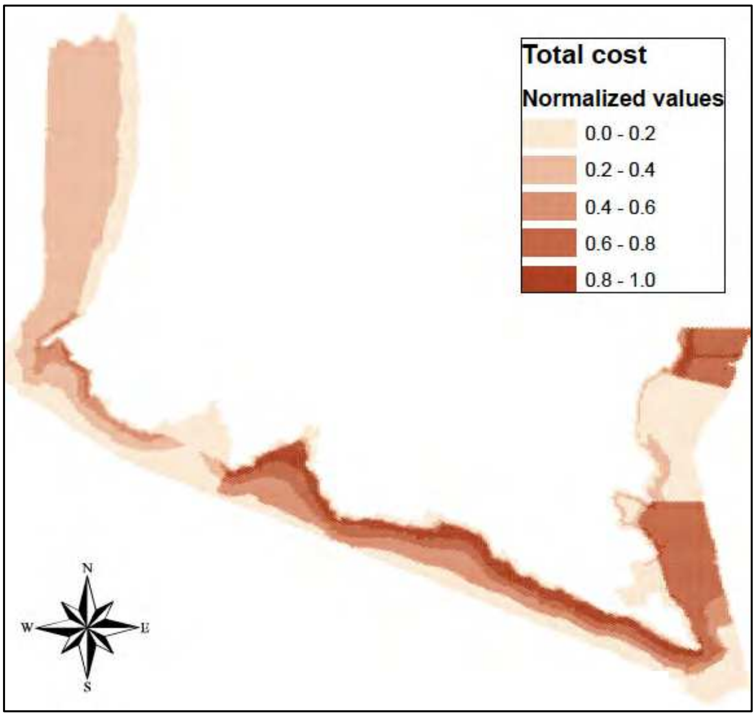

Fig. 3: Total cost of PUs in the study area

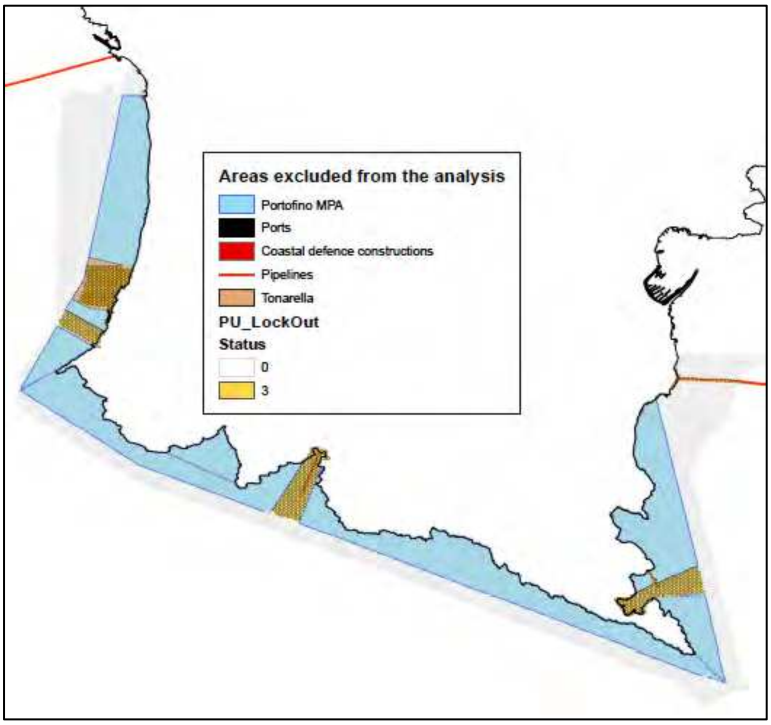

Fig. 4. Study area and areas excluded from the analysis

4.4. Zone effectiveness

Incorporating zone effectiveness into the design of marine zoning requires quantitative data to assess the level that each zone is protecting each species or habitats taking into account the activities and their intensity (Makino et al., 2013). For instance, the no-take zone is expected to have the maximum contribution (100%) to the conservation targets set (Lester et al., 2009). On the contrary, other zones that human activities are present will contribute less to the biodiversity targets (Lester and Halpern, 2008; Mora, 2006). In the current scenario for assessing the contribution of each zone to the overall target, we have adopted the approach implemented in Klein et al. (2010). In this case, the zone contribution is a binary value that undertakes the contribution as zero (= 'no contribution') in the case that the activity is taking place in the zone, or one (= 'contribution to target) in the case it is not present in the specific zone. In the future, more complex approaches are considered in order to address more accurate representation coefficients for zone effectiveness.

4.5. Setting scenarios for the future engagement with stakeholders

In the first scenario we have set four zones in respect to the current MPA zoning plan defining the human activities in space as shown in Table 2. More specifically, in Zone A ('no-take zone'), all activities are prohibited, with the exception of controlled scientific research after an authorization from the MPA authority as is in the current MPA management plan. In Zone B ('regulated zone'), only diving is allowed; in Zone C ('exploited zone'), diving and artisanal fishing are allowed, while in Zone D ('buffer zone'), diving and all types of fishing activities are allowed, except destructive recreational fishing gears (Markantonatou et al., *in prep*.). In the proposed MPA area, spearfishing and anchoring are prohibited.

Table 2. Zoning plan suggested for the developed scenario.

Activities	Zone A	Zone B	Zone C	Zone D
Diving	Not allowed	Allowed*	Allowed*	Allowed
Small scale fishing	Not allowed	Allowed*	Allowed*	Allowed
Recreational fishing	Not allowed	Not allowed	Allowed*	Allowed
Anchoring	Not allowed	Not allowed	Not allowed	Not allowed

** indicates regulated activities*

4.6 Marxan With Zones Analysis

In order to ensure the desired level of spatial compactness in our design, we chose a solution by calibrating the Boundary Length Modifier (BLM) that generates a reasonable trade-off between boundary length and cost (Stewart and Possingham, 2005). We used a BLM value of 0.04 and ran Marxan 300 times. From these runs a best solution, which meets all targets with the lowest cost and boundary penalties was produced. The selection frequency of each PU within a particular zone indicates the proportion of runs in which a site was selected amongst the 300 runs.

5. Results

The spatial distribution of the conservation features and cost will finally identify the management zones in the study area. The highest biodiversity values were found in the south-eastern part of the Promontory. In the same area human activity is high mainly due to the high small scale and diving activities operating at the area.

The suggested 4-zones plan has successfully reached the high targets set for the priority conservation features including the entire study area. As showed in the selection frequency of PUs (Fig. 4), Zone A includes the largest part of the existing no-take zone, while some *Posidonia oceanica* and coralligenous have been selected mainly in the south- eastern part of the promontory. The selection of the existing no-take reserve is due to the fact that the selected PUs have a very low socio-economic opportunity cost since no activity operates there.

Zone B as shown in Fig. 5 is located at the south-eastern part of the promontory. Diving has been successfully selected shallow areas of high aesthetic value formed by the three-dimensional structure organisms of coralligenous that are well known to attract divers. We also notice that zone B includes an important part of coralligenous communities that is subject to 80% of the total diving activity that operates in the area, and are the sites more preferred by divers in Portofino.

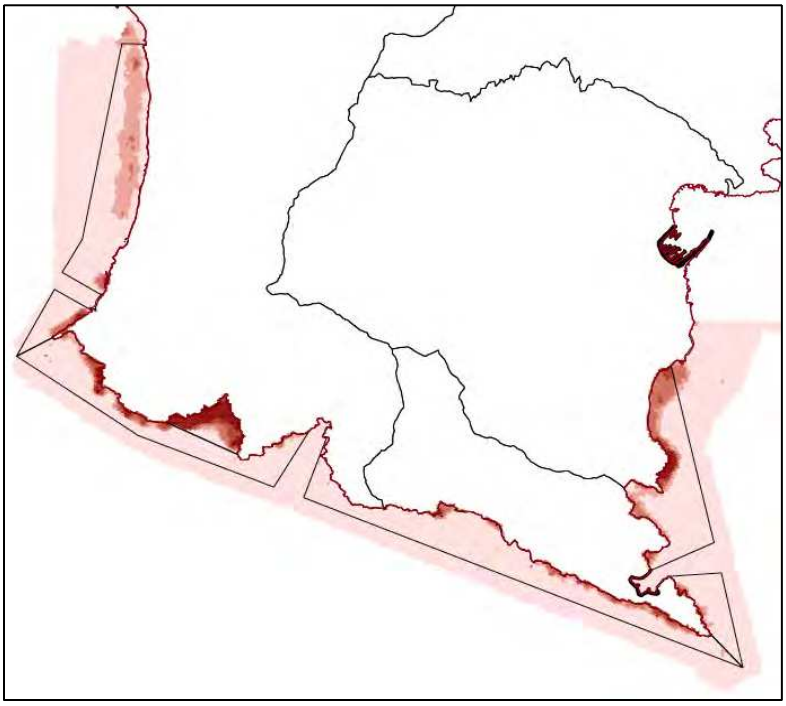

Fig. 4: Selection frequency for zone A “no-take zone”

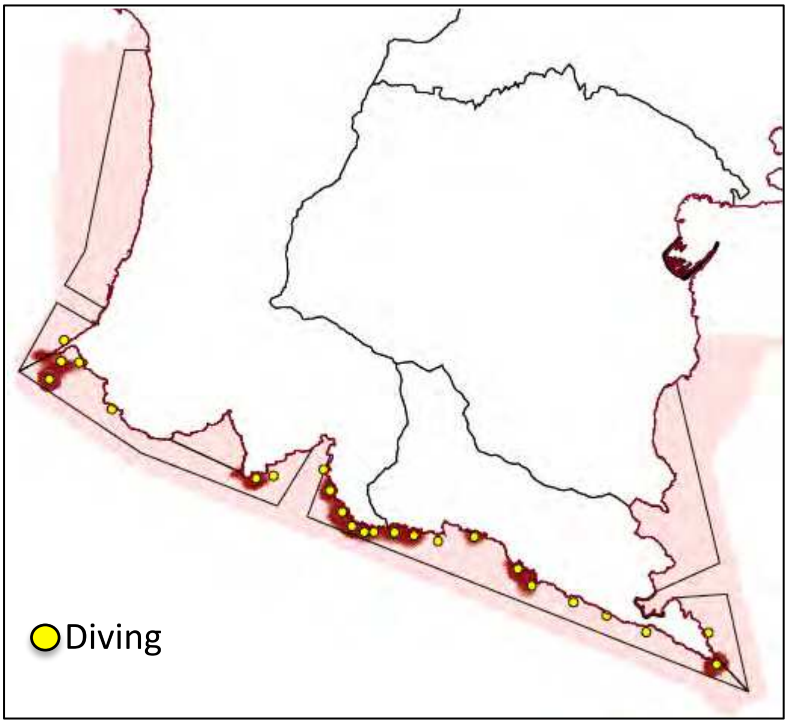

Fig. 5: Selection frequency for zone B “regulated zone”. Yellow bullets represent existing diving sites.

Zone C, the ‘exploitation zone’, is mainly characterized by small-scale fisheries. As fig. 6 indicates, the main fishing grounds of artisanal fishing have been selected. Successful selection of ‘*tonarella*’ has also been achieved, with tonarella operating 6 months per year (April to September), based on existing regulations, and the rest of artisanal fishing operating in this area the other half of the year. We have to highlight that artisanal fishing activity in Portofino MPA decreases with high rates the last years (Markantonatou et al., 2014). Due to the decreasing trends of the small scale fishing sector we expect a future decline of fishing pressure in the selected area.

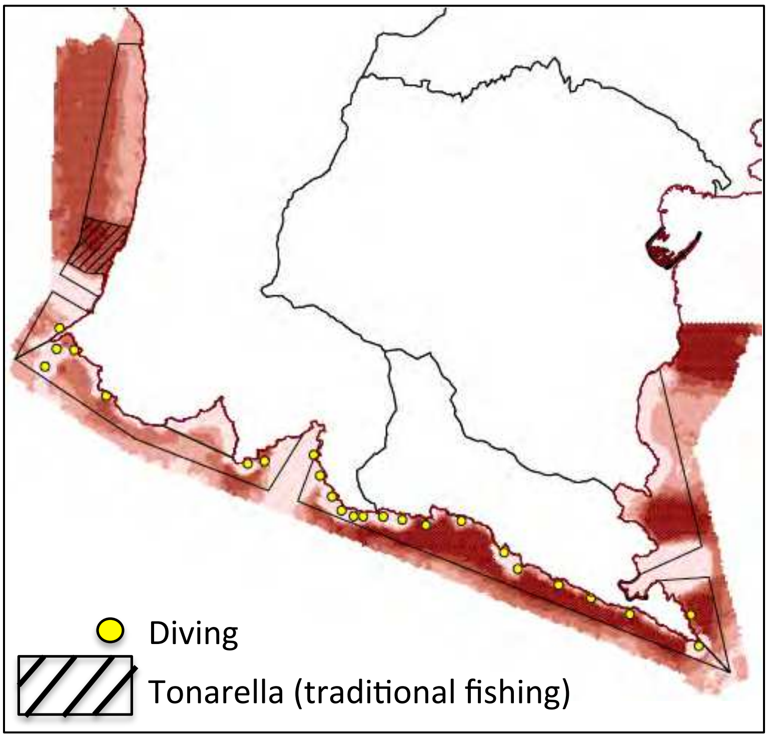

Fig. 6: Selection frequency for zone C “exploitation zone”.

Finally, in zone D (‘buffer zone’), small-scale and recreational fishing are allowed, with the exception of spearfishing and potentially destructive recreational fishing practices. From Fig. 7 we observe that zone D is allocated in the area excluded from the analysis due to human threats for biodiversity, such as ports and their corridors. Although conservation targets have been reached this is probably an indication that the spatial extend of the study area is limited in order to simultaneously fit all the activities and reach biodiversity objectives.

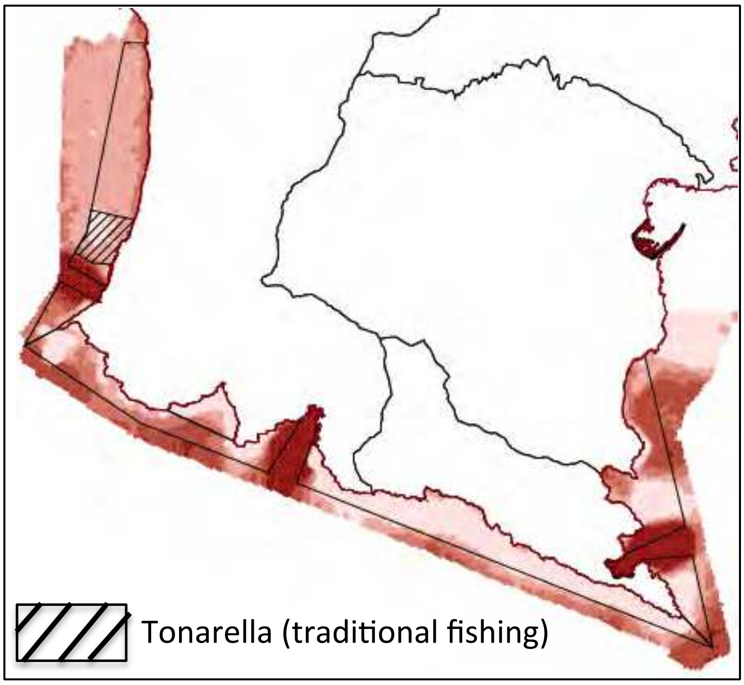

Fig. 7: Selection frequency for zone D "buffer zone"

6. Discussion

In the Mediterranean and Black Seas, less than 1% of the surface is considered pristine, without being impacted by humans (Micheli and Niccolini, 2013). Moreover, their selection and establishment of the majority of existing MPAs, is based mainly on experts' criteria and ad-hoc processes focused on economic and political criteria (Thiel et al., 2007; Vega, 2011). As biodiversity is threatened by cumulating human activities impacting marine ecosystems (Halpern et al., 2008), there is an increasing urgency of implementing systematic conservation methods and establish long-term sustainable management plans for effective conservation of the oceans (Pressey et al., 2007). This suggests that the need for the establishment of new protected areas should be considered of equal priority to the improvement of the management in existing MPAs.

Portofino MPA represents a common challenge in conservation planning, where high biodiversity features and geomorphological hot-spots are often targets for human activities such as fishing and diving (Clark and Koslow, 2007). In addition to the extremely small surface area of the MPA, this simultaneously signifies the emergence of conflicts between users and the need for urgent action in order to keep the system in a good status.

We have applied Marxan With Zones DST for providing advice regarding a future enlargement and re- zoning plan in Portofino MPA. Conservation planning tools such as Marxan With Zones may simplify the complexity in decision-making by permitting maximization of the long-term conservation goals and minimization of the area protected and the associated conservation costs (Leslie et al., 2003). Using Marxan With Zones, we were able to produce solutions that were spatially compact (Roberts et al., 2003). We have suggested an expanded area of almost double size than the current MPA in order to increase the likelihood of the area to support mobile organisms, and its the capacity of recovering after an impact (McLeod et al., 2009). The four-zoning spatial plan combines high conservation targets achieved with the least possible socio-economic cost for managers, policy-makers and stakeholders. Our plan integrates priority habitats and vulnerable species sensitive to different human impacts and identifies important habitats that currently their protection status is low (e.g. *Cystoseira* forests, coralligenous). However, in order to promote the local economy and tradition of the area, in accordance to the MPA's objectives, targets were not only set for the protection of biodiversity, but also for maintaining some compatible uses of resources in the Portofino MPA (small-scale, recreational fishing and diving). The success of the plan to configure the zones in space lies in the fact that the selected areas were popular in the relevant user groups. For instance, diving that is feasible in relevantly shallow areas (average about 40m depth) with coralligenous and rich fish biodiversity present; popular fishing grounds and the *'tonarella' location* in the 'exploitation' zone (zone C). Therefore this plan is considered realistic and is not expected to raise much opposition from stakeholders, although definitively changes will be made during the engagement with them.

Updated information regarding human activities and conservation features, along with ecological modelling and acoustic data, as provided by MMMPA project were able to enrich information producing innovative and precise results. However, with the current level of targets in terms of ecological and socio-economic objectives, the size of the suggested MPA is still considered inadequate to include recreational fishing within the protected area. It has been shown that a clear and simple shape of an MPA influences conservation performance as it allows for habitat continuity, enforcement of boundaries and minimization of edge effects (McLeod et al., 2009 and references therein). Other challenges encountered during the analysis were the shape of the study area and the heterogeneous distribution of the features that made difficult the aggregation of PUs into continuous zones. However in the future other scenarios are planned to be tested and provide more alternative solutions to Portofino MPA managers. One of the challenges is to apply accurate coefficients that better describe the impact of different levels of pressures on each conservation feature ('zone effectiveness'). Integration with other models, such as the ECOSPACE model for the development of scenarios are expected to improve the efficiency of conservation planning outputs.

In the present study a first attempt was made to suggest an enlargement of Portofino MPA and re-zoning to support high conservation targets using Marxan with Zones. Advanced decision support tools (DSTs) such as Marxan and Marxan with Zones, allow systematic and transparent selection methods for locating areas to conserve integrating a combination of characteristics (Rojas Nazar et al., 2012). These tools advance, since multiple social and economic constraints can be integrated into a planning unit's cost and may solve the most complicated spatial problems in an area (Stewart and Possingham, 2005). Therefore they should be considered during an MPA establishment the MPA establishment to support direct and targeted conservation strategy. When applied subsequently to the MPA establishment, Marzan With Zones may reveal significant gaps in existing management plans and improve them significantly (Giakoumi et al., 2013).

The outcomes of this study provide a possible conservation solution that negotiation should be based on in a future stakeholder engagement process. Conservation planning should be a participatory process where stakeholders develop a mutual understanding on the existing information and reach a common consensus and generation of possible solutions (Pomeroy and Douvere, 2008). We highly recommend that the conservation initiative in Portofino MPA should be initiated with the identification and involvement of stakeholders as suggested in (Markantonatou et al., 2015a) in order to negotiate and integrate the stakeholders' perspective in the analysis. Regular meetings, awareness and trust-bonded relations with users are expected to improve the quality of monitoring and sound governance of marine resources. It is also important to highlight that the conservation planning does not stop here. When the plan is finalized and implemented, its persistence must be ensured through monitoring, patrolling and law enforcement (Margules and Pressey, 2000). Finally, the MPA's management board should make effort regarding the communication conservation and decisions that will secure guarantee compliance and social control towards adaptive management of marine resources.

References

Abdulla, A., Gomei, M., Maison, E., 2008. Status of Marine Protected Areas in the Mediterranean Sea. World Conservation Union.

Agardy, T., 2010. Ocean Zoning: Making Marine Management More Effective. London: Earthscan.

Agostini, V.N., Margles, S.W., Schill, S.R., Knowles, J.E., Blyther, R.J., 2010. Marine zoning in Saint Kitts and Nevis, The Nature Conservancy. USA.

Allnutt, T.F., McClanahan, T.R., Andréfouët, S., Baker, M., Lagabrielle, E., McClennen, C., Rakotomanjaka, A.J.M., Tianarisoa, T.F., Watson, R., Kremen, C., 2012. Comparison of marine spatial planning methods in Madagascar demonstrates value of alternative approaches. PLoS ONE 7, e28969. doi:10.1371/journal.pone.0028969

Almany, G.R., Berumen, M.L., Thorrold, S.R., Planes, S., Jones, G.P., 2007. Local Replenishment of coral reef fish populations in a Marine Reserve. Science 316, 742–744. doi:10.1126/science.1140597

Babcock, R.C., Shears, N.T., Alcala, A.C., Barrett, N.S., Edgar, G.J., Lafferty, K.D., McClanahan, T.R., Russ, G.R., 2010. Decadal trends in marine reserves reveal differential rates of change in direct and indirect effects. Proc. Natl. Acad. Sci. U.S.A. 107, 18256–18261. doi:10.1073/pnas.0908012107

Ball, I.R., Possingham, H.P., Watts, M., 2009. Marxan and relatives: Software for spatial conservation prioritisation., in A. Moilanen, K.A.Wilson, H.P. Possingham (Eds), Spatial conservation prioritisation: Quantitative methods and computational tools, pp. 185-195.

Ban, N.C., Bodtker, K.M., Nicolson, D., Robb, C.K., Royle, K., 2013. Setting the stage for marine spatial planning: Ecological and social data collation and analyses in Canada's Pacific waters. Marine Policy 39, 11–20. doi:10.1016/j.marpol.2012.10.017

Barr, L.M., Possingham, H.P., 2013. Are outcomes matching policy commitments in Australian marine conservation planning? Marine Policy 42, 39–48. doi:10.1016/j.marpol.2013.01.012

Britten, G.L., Dowd, M., Minto, C., Ferretti, F., Boero, F., Lotze, H.K., 2014. Predator decline leads to decreased stability in a coastal fish community. Ecology Letters 17, 1518–1525. doi:10.1111/ele.12354

Bruce, E.M., Eliot, I.G., 2006. A spatial model for Marine Park zoning. Coastal Management 34, 17–38. doi:10.1080/08920750500364898

Butt, N., Beyer, H.L., Bennett, J.R., Biggs, D., Maggini, R., Mills, M., Renwick, A.R., Seabrook, L.M., Possingham, H.P., 2013. Biodiversity risks from fossil fuel extraction. Science 342, 425–426. doi:10.1126/science.1237261

Cabeza, M., 2003. Habitat loss and connectivity of reserve networks in probability approaches to reserve design. Ecology Letters 6, 665–672. doi:10.1046/j.1461-0248.2003.00475.x

Cattaneo-Vietti, R., Cappanera, V., Castellano, M., Povero, P., 2015. Yield and catch changes in a Mediterranean small tuna trap: a warming change effect? Mar Ecol 36, 155–166. doi:10.1111/maec.12127

Clarke, P., Jupiter, S., 2010. Principles and practice of ecosystem-based management: a guide for conservation practitioners in the tropical western pacific. Wildlife Conservation Society. Suva, Fiji

Clark, M.R., Koslow, J.A., 2007. Impacts of Fisheries on Seamounts. Blackwell Publishing Ltd, Oxford, UK. doi:10.1002/9780470691953.ch19

Costantini, F., Carlesi, L., Abbiati, M., 2013. Quantifying spatial genetic structuring in mesophotic populations of the precious Coral Corallium rubrum. PLoS

ONE 8, e61546. doi:10.1371/journal.pone.0061546
Costantini, F., Rossi, S., Pintus, E., Cerrano, C., Gili, J.M., Abbiati, M., 2011. Low connectivity and declining genetic variability along a depth gradient in Corallium rubrum populations. Coral Reefs 30, 991–1003. doi:10.1007/s00338-011-0771-1
Cowen, R.K., Paris, C.B., Srinivasan, A., 2006. Scaling of connectivity in marine populations. Science 311, 522–527. doi:10.1126/science.1122039
Diviacco, G., Coppo, S., 2006. Atlante degli habitat marini della Liguria. Centro Stampa Offset, Genova.
Douvere, F., 2008. The importance of marine spatial planning in advancing ecosystem-based sea use management. Marine Policy 32, 762–771. doi:10.1016/j.marpol.2008.03.021
Edgar, G.J., 2011. Does the global network of marine protected areas provide an adequate safety net for marine biodiversity? Aquatic Conserv: Mar. Freshw. Ecosyst. 21, 313–316. doi:10.1002/aqc.1187
Edgar, G.J., Stuart-Smith, R.D., Willis, T.J., Kininmonth, S., 2014. Global conservation outcomes depend on marine protected areas with five key features. Nature 506, 216–220. doi:10.1038/nature13022
Ehler, C., Douvere, F., 2009. Marine spatial planning: a step-by-step approach toward ecosystem-based management.
Fernandes, L., Day, J., Lewis, A., Slegers, S., Kerrigan, B., Breen, D., Cameron, D., Jago, B., Hall, J., Lowe, D., Innes, J., Tanzer, et al., 2005. Establishing Representative No-Take Areas in the Great Barrier Reef: Large-Scale Implementation of Theory on Marine Protected Areas. Conservation Biology 19, 1733–1744. doi:10.1111/j.1523-1739.2005.00302.x
Foley, M.M., Halpern, B.S., Micheli, F., Armsby, M.H., 2010. Guiding ecological principles for marine spatial planning. Marine Policy 34, 955–966. doi:10.1016/j.marpol.2010.02.001
Gell, F.R., Roberts, C.M., 2003. Benefits beyond boundaries: the fishery effects of marine reserves. Trends Ecol. Evol. (Amst.) 18, 448–455. doi:10.1016/S0169-5347(03)00189-7
Giakoumi, S., Katsanevakis, S., Vassilopoulou, V., Panayotidis, P., Kavadas, S., Issaris, Y., Kokkali, A., Frantzis, A., Panou, A., Mavrommati, G., 2012. Could European marine conservation policy benefit from systematic conservation planning? Aquatic Conserv: Mar. Freshw. Ecosyst. 22, 762–775. doi:10.1002/aqc.2273
Giakoumi, S., Sini, M., Gerovasileiou, V., Mazor, T., Beher, J., Possingham, H.P., Abdulla, A., Çinar, M.E., Dendrinos, P., Gucu, A.C., Karamanlidis, A.A., Rodic, P., Panayotidis, P., Taskin, E., Jaklin, A., Voultsiadou, E., Webster, C., Zenetos, A., Katsanevakis, S., 2013. Ecoregion-Based Conservation Planning in the Mediterranean: Dealing with large-scale heterogeneity. PLoS ONE 8, e76449. doi:10.1371/journal.pone.0076449
Gianni, G., Mangialajo, L., 2015. Guidelines for the conservation, monitoring and restoration of Cystoseira forests in the Mediterranean Sea. MMMPA Deliverable D1.2.4, Nice, France. 8pp.
Green, A., Centre, N.C.A.I.-P.R., United States. Agency for International Development, David & Lucile Packard Foundation, 2007. Scientific Design of a Resilient Network of Marine Protected Areas.
Halpern, B.S., Walbridge, S., SELKOE, K.A., KAPPEL, C.V., Micheli, F., D'Agrosa, C., Bruno, J.F., Casey, K.S., Ebert, C., Fox, H.E., Fujita, R., Heinemann, D., Lenihan, H.S., Madin, E.M.P., Perry, M.T., Selig, E.R., Spalding, M., Steneck, R., Watson, R., 2008. A global map of human impact on marine ecosystems. Science 319, 948–952. doi:10.1126/science.1149345
Higgs, A.J., 1981. Island biogeography theory and nature reserve design. Journal of Biogeography 8, 117. doi:10.2307/2844554
Hilborn, R., Micheli, F., De Leo, G.A., 2006. Integrating marine protected areas with catch regulation. Canadian Journal of Fisheries and Aquatic Sciences 63, 642–649.

doi:10.1139/f05-243
Kirkpatrick, S., Gelatt, C.D., Vecchi, M.P., 1983. Optimization by simulated annealing. Science 220, 671–680. doi:10.1126/science.220.4598.671
Klein, C.J., Chan, A., Kircher, L., Cundiff, A.J., Gardner, N., Hrovat, Y., Scholz, A., Kendall, B.E., Airamé, S., 2008. Striking a balance between biodiversity conservation and socioeconomic viability in the design of marine protected areas. Conservation Biology 22, 691–700. doi:10.1111/j.1523-1739.2008.00896.x
Klein, C.J., Steinback, C., Watts, M., Scholz, A.J., Possingham, H.P., 2010. Spatial marine zoning for fisheries and conservation. Frontiers in Ecology and the Environment 8, 349–353. doi:10.1890/090047
Kukkala, A.S., Moilanen, A., 2013. Core concepts of spatial prioritisation in systematic conservation planning. Biol Rev Camb Philos Soc 88, 443–464. doi:10.1111/brv.12008
Leslie, H., Ruckelshaus, M.H., Ball, I.R., 2003. Using siting algorithms in the design of marine reserve networks. Ecological Applications 13, 185–198. doi:10.1890/1051-0761(2003)013[0185:usaitd]2.0.co;2
Lester, S.E., Halpern, B.S., 2008. Biological responses in marine no-take reserves versus partially protected areas. Mar. Ecol. Prog. Ser.
Lester, S.E., Halpern, B.S., Grorud-Colvert, K., 2009. Biological effects within no-take marine reserves: a global synthesis. Mar Ecol 384, 33–46. doi:10.3354/meps08029
Makino, A., Klein, C.J., Beger, M., Jupiter, S.D., Possingham, H.P., 2013. Incorporating Conservation Zone Effectiveness for Protecting Biodiversity in Marine Planning. PLoS ONE 8, e78986. doi:10.1371/journal.pone.0078986
Margules, C.R., Pressey, R.L., 2000. Systematic conservation planning. Nature 405, 243–253. doi:10.1038/35012251
Markantonatou, V., Marconi, M., Cappanera, V., Campodonico, P., Bavestrello, A., Cattaneo-Vietti, R., Papadopoulou, N., Smith, C., Cerrano, C., 2014. Spatial allocation of fishing activity on coralligenous habitats in Portofino MPA (Liguria, Italy), in: Bouafif, C., Langar, H., Ouerghi, A. (Eds.). Presented at the UNEP/MAP- RAC/SPA, Proceedings of the second Mediterranean Symposium on the conservation of Coralligenous and other Calcareous Bio-Concretions. Portorož, Slovenia, 29-30 October 2014, Portorož, Slovenia, pp. 118–123.
Markantonatou, V., Noguera-Méndez, P., Semitiel-García, M., Hogg, K., Sano, M., 2015a. Social networks and information flow: building the ground for collaborative marine conservation planning in Portofino Marine Protected Area (MPA). Journal of Ocean and Coastal Management. In press.
Markantonatou, V., Marconi, M., Cerrano, C., 2015b. Guidelines for monitoring pressure and impacts from small scale and recreational fishing activity in Mediterranean Marine Protected Areas, MMMPA Deliverable D5.2.4, Ancona, Italy. pp.13.
Markantonatou, V., Papadopoulou, N., Smith, C., Cerrano, C. Pressure-risk assessment of fishing activity on coralligenous habitats. In prep.
Mazor, T., Possingham, H.P., Edelist, D., Brokovich, E., Kark, S., 2014. The crowded sea: Incorporating multiple marine activities in conservation plans can significantly alter spatial priorities. PLoS ONE 9, e104489. doi:10.1371/journal.pone.0104489
McLeod, E., Salm, R., Green, A., Almany, J., 2009. Designing marine protected area networks to address the impacts of climate change. Frontiers in Ecology and the Environment 7, 362–370. doi:10.1890/070211
Micheli, F., Niccolini, F., 2013. Achieving success under pressure in the conservation of intensely used coastal areas. Ecology and Society 18, art19. doi:10.5751/ES-05799-180419
Mora, C., 2006. Coral reefs and the global metwork of Marine Protected Areas. Science 312, 1750–1751. doi:10.1126/science.1125295
Mumby, P.J., 2006. Connectivity of reef fish between mangroves and coral reefs:

Algorithms for the design of marine reserves at seascape scales. Biological Conservation 128, 215–222. doi:10.1016/j.biocon.2005.09.042

Naidoo, R., Adamowicz, W.L., 2006. Modeling opportunity costs of conservation in transitional landscapes. Conservation Biology 20, 490–500. doi:10.1111/j.1523-1739.2006.00304.x

Olsen, E., Kleiven, A.R., Skjoldal, H.R., Quillfeldt, von, C.H., 2010. Place-based management at different spatial scales. J Coast Conserv 15, 257–269. doi:10.1007/s11852-010-0108-1

Pomeroy, R., Douvere, F., 2008. The engagement of stakeholders in the marine spatial planning process. Marine Policy 32, 816–822. doi:10.1016/j.marpol.2008.03.017

Portman, M.E., 2007. Zoning design for cross-border marine protected areas: The Red Sea Marine Peace Park case study. Ocean & Coastal Management 50, 499–522. doi:10.1016/j.ocecoaman.2007.02.008

Possingham, H., Wilson, K.A., Andelman, S.J., Vynne, C.H., 2006. Protected areas: goals, limitations, and design. In Martha J. Groom, Gary K. Meffe and C. Ronald Carroll (Ed.), Principles of Conservation Biology3rd ed. ed. (pp. 507-549) Sunderland, Massachusetts, U.S.: Sinauer Associates.

Prato, G., Barrier, C., Francour, P., Markantonatou, V., Cappanera, V.,Guidetti, P., Cattaneo-Vietti, R., Mangialajo, L., Gascuel, D. A trophic modelling approach to assess artisanal and recreational fisheries impacts and conflicts in MPAs, *In prep.*

Pressey, R.L., Cabeza, M., Watts, M.E., Cowling, R.M., Wilson, K.A., 2007. Conservation planning in a changing world. Trends Ecol. Evol. (Amst.) 22, 583–592. doi:10.1016/j.tree.2007.10.001

Roberts, C.M., Branch, G., Bustamante, R.H., 2003. Application of ecological criteria in selecting marine reserves and developing reserve networks. Ecological … 13, 215–228. doi:10.1890/1051-0761(2003)013[0215:AOECIS]2.0.CO;2

Rojas Nazar, Ú., Gaymer, C.F., Squeo, F.A., Garay-Flühmann, R., López, D., 2012. Combining information from benthic community analysis and social studies to establish no-take zones within a multiple uses marine protected area. Aquatic Conserv: Mar. Freshw. Ecosyst. 22, 74–86. doi:10.1002/aqc.1239

Ruiz-Frau, A., Kaiser, M.J., Edwards-Jones, G., Klein, C.J., 2015. Balancing extractive and non-extractive uses in marine conservation plans. Marine Policy 52, 11–18. doi:10.1016/j.marpol.2014.10.017

Salm, R.V. and S.L. Coles (eds). 2001. Coral Bleaching and Marine Protected Areas. Proceedings of the Workshop on Mitigating Coral Bleaching Impact Through MPA Design, Bishop Museum, Honolulu, Hawaii, 29-31 May 2001. Asia Pacific Coastal Marine Program Report # 0102, The Nature Conservancy, Honolulu, Hawaii, U.S.A: 118 pp

Salmona, P., Verardi, D., 2001. The marine protected area of Portofino, Italy: a difficult balance. Ocean & Coastal Management 44, 39–60. doi:10.1016/S0964-5691(00)00084-3

Soule, M.E., 1987. Viable Populations for Conservation, Cambridge University Press.

Stewart, R.R., Possingham, H.P., 2005. Efficiency, costs and trade-offs in marine reserve system design. Environmental Modeling & Assessment 10, 203–213. doi:10.1007/s10666-005-9001-y

Thiel, M., Macaya, E.C., Acuna, E., Arntz, W.E., 2007. The humboldt current system of northern and central Chile: oceanographic processes, ecological interactions and socioeconomic feedback. … and Marine Biology.

Vega, C., 2011. Criterios que Guiaron la Declaración de las Áreas Marinas Protegidas en las Regiones de Atacama y Coquimbo, Chile. Coquimbo, Chile.

Villa, F., Tunesi, L., Agardy, T., 2002. Zoning Marine Protected Areas through spatial multiple-criteria analysis: the case of the Asinara Island national Marine Reserve of Italy. Conservation Biology 16, 515–526. doi:10.1046/j.1523-1739.2002.00425.x

Watts, M.E., Ball, I.R., Stewart, R.S., Klein, C.J., 2009. Marxan with Zones: software for optimal conservation based land-and sea-use zoning. Environmental Modelling and Software 24, 1513–1521. doi:10.1016/j.envsoft.2009.06.005

Watts, M.E., Klein, C.K., Stewart, R.S., Ball, I.R., Possingham, H.P., 2008. Marxan with Zones (v1.0.1). Conservation Zoning using Spatially Explicit Annealing, Ecotrust, the National Heritage Trust and the Applied Environmental Decision Analysis centre.

Wilson, K.A., Cabeza, M., Klein, C.J., 2009a. Fundamental concepts of spatial conservation prioritization, in: Moilanen, A., Wilson, K.A., Possingham, H.P. (Eds.), Spatial Conservation Prioritization: Quantitative Methods and Computational Tools, Oxford, New York, p. 304.

Wilson, K.A., Carwardine, J., Possingham, H.P., 2009b. Setting conservation priorities. Annals of the New York Academy of Sciences the Year in Ecology and Conservation Biology 1162, 237–264.

Zapata-Ramirez, P.A., Huete-Stauffer, C., Markantonatou, V., Riccioni, G., Marconi, M. and Cerrano, C., 2014. Multiscale modelling of Portofino's MPA commercial fish population, 2014. Towards a new ecosystem-based management approach. 49th European Marine Biology Symposium, Zoological Institute, Russian Academy of Sciences, September 8–12, St. Petersburg, Russia.

Zapata-Ramirez, P.A; Huete-Stauffer, C; Scaradozzi, D; Marconi, M and Cerrano, C., 2015a. Mapping and modelling the distribution of coralligenous and cave environments, a multi approach to assess the Good Environmental Status (GES) at Portofino MPA. Ecological Indicators. *Submitted*.

Chapter VII

The ITN MMMPA experience and networking

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Abstract

The scope of the network drawn for the Marie Curie Initial Training Network Monitoring of Mediterranean Marine Protected Areas (MMMPA ITN) has been to shape the profile of the next generation of MPAs managers. Considering the key role of MPAs in achieving the biodiversity conservation targets fixed at international level, and the high discrepancy in the actual management between the existing Mediterranean MPAs, it is pivotal to reinforce these with concrete measures of management and governance capacity. The MMMPA ITN is structured through 5 scientific work packages and 10 inter-related sub-programmes. Based on the proposal, deliverables were set accounting only for a theoretical degree of interaction among partners. However, during the project lifetime, some of the predefined deliverables changed both in relation to difficulties in obtaining data and to implement new opportunities. Here we apply Social Network Analysis (SNA) techniques to describe the evolution of the MMMPA's social network, in order to document how the different Early Stage Researchers (ERSs) were connected throughout the project, and highlight how these interactions allowed the reaching of the final expected outcomes.
The analysis indicates that - although initially fragmented groups were formed in the network - ESRs progressively established connections across individual deliverables and built collaborations through a dynamic process of continuous interaction and communication, which resulted in a cohesive scientific network. It is expected that this network will continue to grow and strengthen as the ESRs will keep collaborating and explore new career perspectives under a shared vision that has been developed for the future resource management in the Mediterranean Sea.

Keywords: Social Network Analysis; Collaboration networks; European Projects; MMMPA; Initial Training Network

1. Introduction

The aim of the Marie Curie Initial Training Network Monitoring of Mediterranean Marine Protected Areas (MMMPA ITN) was to train the next generation of MPA managers. The MMMPA ITN project was structured through 5 scientific work packages and 10 inter-related sub-programmes. MMMPA is a joint research endeavour between 5 work packages (WPs) (both social and natural sciences). The 10 projects within the WP's include research into ecological and social processes that affect the health of the marine environment and the creation of tools to aid practitioners, stakeholders and governments plan for more effective marine management.

MMMPA initiated with the following partners: 5 Universities, 1 Research Centre, 1 SME and 5 MPAs (Fig. 1). Throughout the life of the project an additional 2 MPAs, 1 SMA and research centre joined sharing with the MMMPA network their expertise and practical experience in MPA management. A unique opportunity was offered to MMMPA fellows to visit as many of these project partners as desired. The aim of these 'secondments' was to provide them first hand experience of the day to day management of MPAs, and helped develop a set of multidisciplinary skills.

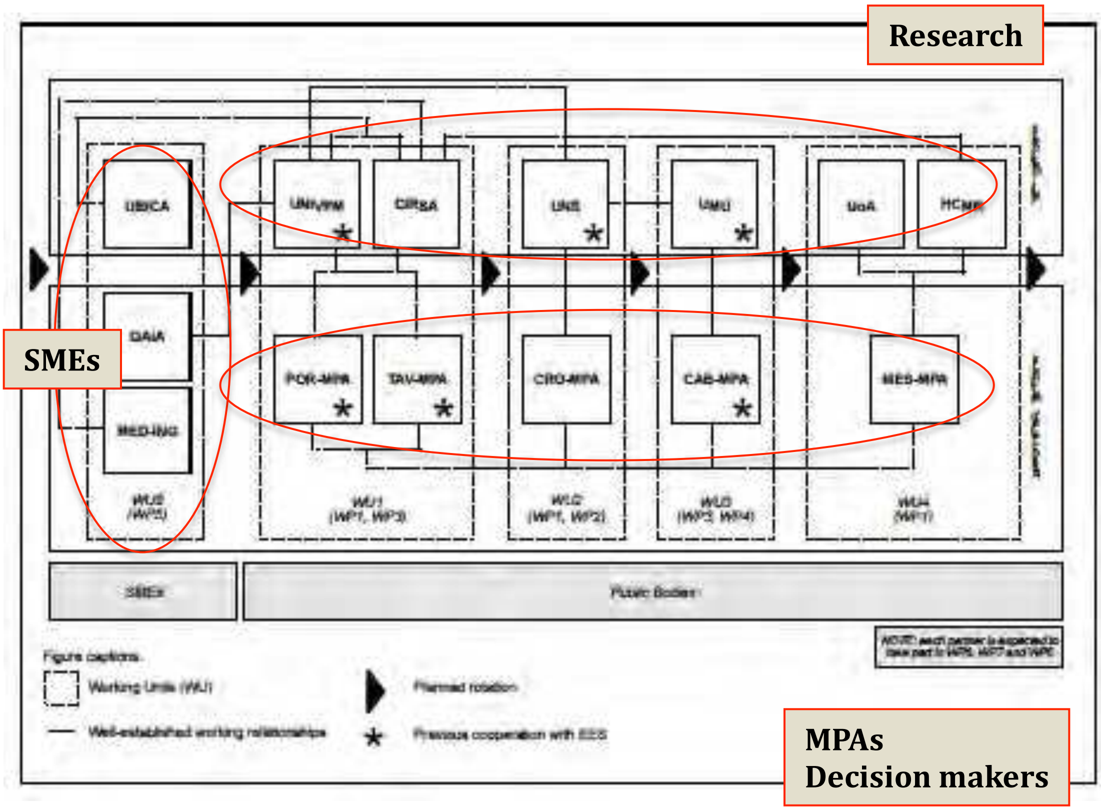

Figure 1. MMMPA Project structure. From MMMPA Proposal, adjusted by C. Cerrano

The research fellows first met in 2012 when the project began. From the onset they have worked closely together finding ways to collaborate and integrate their research projects, and offering one another insight and lessons learned from their primary case study MPA. This combined with the secondments has offered the fellows the chance to gain an in depth understanding and allowed them to explore what aspects of management are working well and which could be strengthened. Collaborations and interaction also developed outside the borders of the project where fellows attended external courses and training events to develop their technical skills and expertise e.g. in the use of relevant tools and concepts that would support the prestige of their research projects. The aim of MMMPA has not been solely focused on scientific achievements but rather on ensuring that the research outputs are suitable for MPA managers and policy makers and as such can be readily utilised in decision-making. In addition fellows have focused their energy on disseminating their findings to the wider public, presenting their data at various International Conferences and public events, producing stakeholder feedback reports, holding stakeholder feedback meetings and through the media and production of outreach videos (Fig. 2).

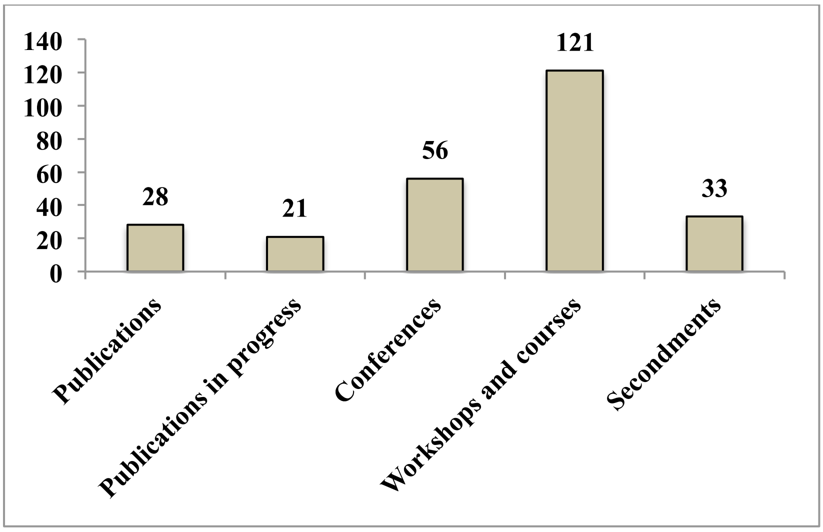

Figure 2. Total number of Conferences, trainings and publications accomplished by MMMPA Researchers

2. Methods

Social Network Analysis (SNA) offers a novel approach to illustrate the evolution of the MMMPA's social network. In so doing, researchers completed a table stating their collaborations and characterizing the type of collaboration established (e.g. shared publications or deliverables, field work etc.). SNA was applied in order to measure the networks' properties and cohesion during the launching and the completion of the project. More specifically, indicators such as (i) average degree (average number of ties); (ii) average distance (average path length between any two actors); density (the proportion of all possible links present in a network); centralization (the extent a network is dominated by single actors); compactness (the harmonic mean of the normalized sum of the reciprocal of all the distances); connectedness (the number of nodes that would have to be removed in order for one actor to no longer be able to reach another); fragmentation (the extent to which the network is divided into separate , non-overlapping sub-networks) were measured (Borgatti and Everett, 2006; Wasserman and Faust, 1994).

3. Results

Social Network Analysis (SNA) offers a novel approach to illustrate the evolution of the MMMPA's social network. The fellows development and collaboration throughout the project's life can be visualised and highlights how these connections have led to the success of the project and delivery of the final expected project outputs (Table 1).

Table 1.
MMMPA social network' s properties during the first (2013) and last year (2015) of the project

Network cohesion	2013	2015
Aver. degree	1	3.059
Density	0.077	0.191
Aver. Distance	1.125	2.096
Centralization	0.09	0.279
Compactness	0.082	0.401
Connectedness	0.088	0.691
Fragmentation	0.912	0.309

The observed fragmented network of 2013 is characterized by collaborations developed between researchers based on common Work Packages that shared similar objectives and within the same hosting countries. On the contrary, in 2015 there is a significant progress in teamwork at all scientific levels and spatial scales. As shown in Table 1, the average numbers of ties (average degree) and the density of links developed between Researchers that integrate their scientific results have significantly increased during this period. The average distances that connect the fellows have also been minimized and the network functions as an entity allowing information and ideas to flow within a compacted and well-connected network. The high connectivity is another indicator of the multiple linkages developed between the fellows hence a signal has multiple ways to reach from one to the other researcher.

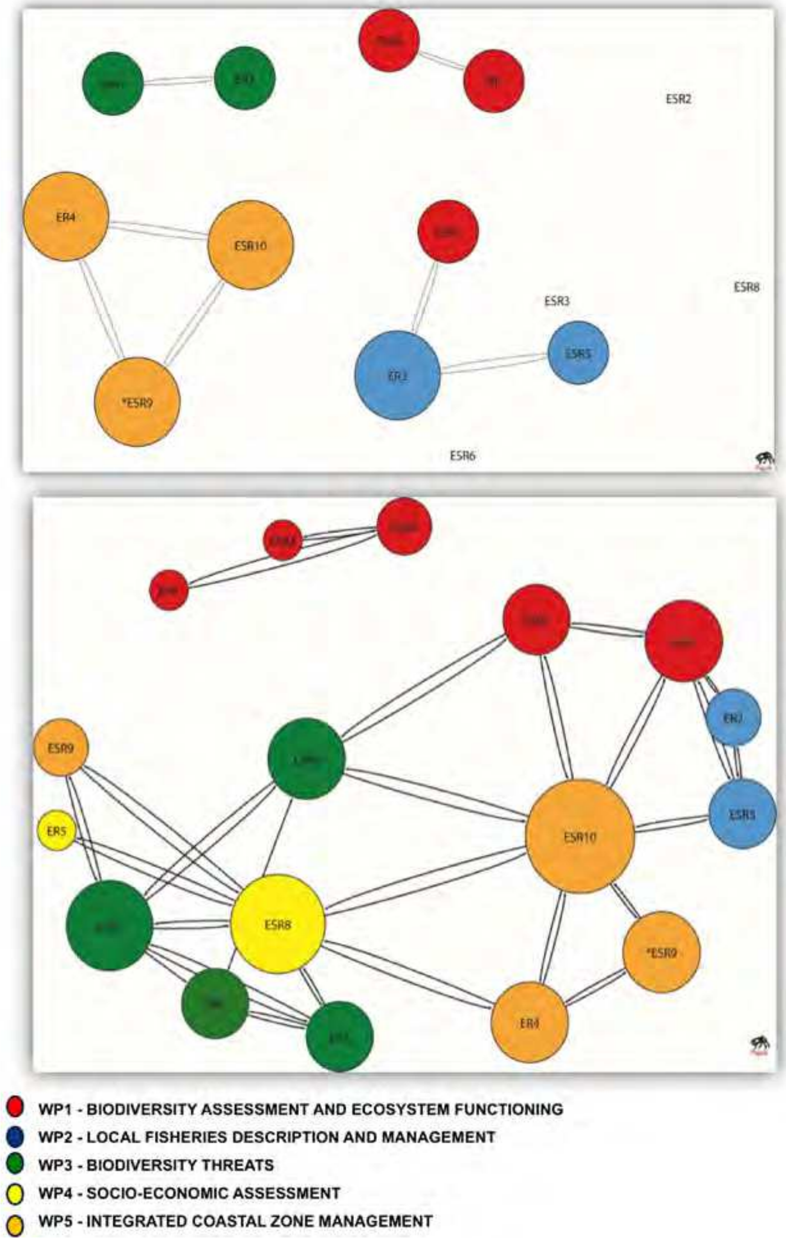

Figure 3. Evolution of MMMPA collaboration network during the project's lifetime.
Size of nodes indicates the number of collaborations developed by every Researcher (degree centrality) and colors the project's Work Packages

The analysis illustrates how a group of unconnected individuals and entities have forged relationships and formed a network over the last 3 years. Throughout the life of the project, the fellows have progressively established connections, which has been encouraged by the annual training events, simultaneous secondments, and the necessity to complete shared deliverables. The result of all these activities has been to create continuous interaction and communication between the fellows allowing experience and expertise to be shared efficiently within this cohesive scientific network. In addition the fellows network has been significantly increased through their attendance to training events both internal and external to the project which were attended by other young researchers, offering the students the ability to create both personal and professional connections with a much wider net of individuals.

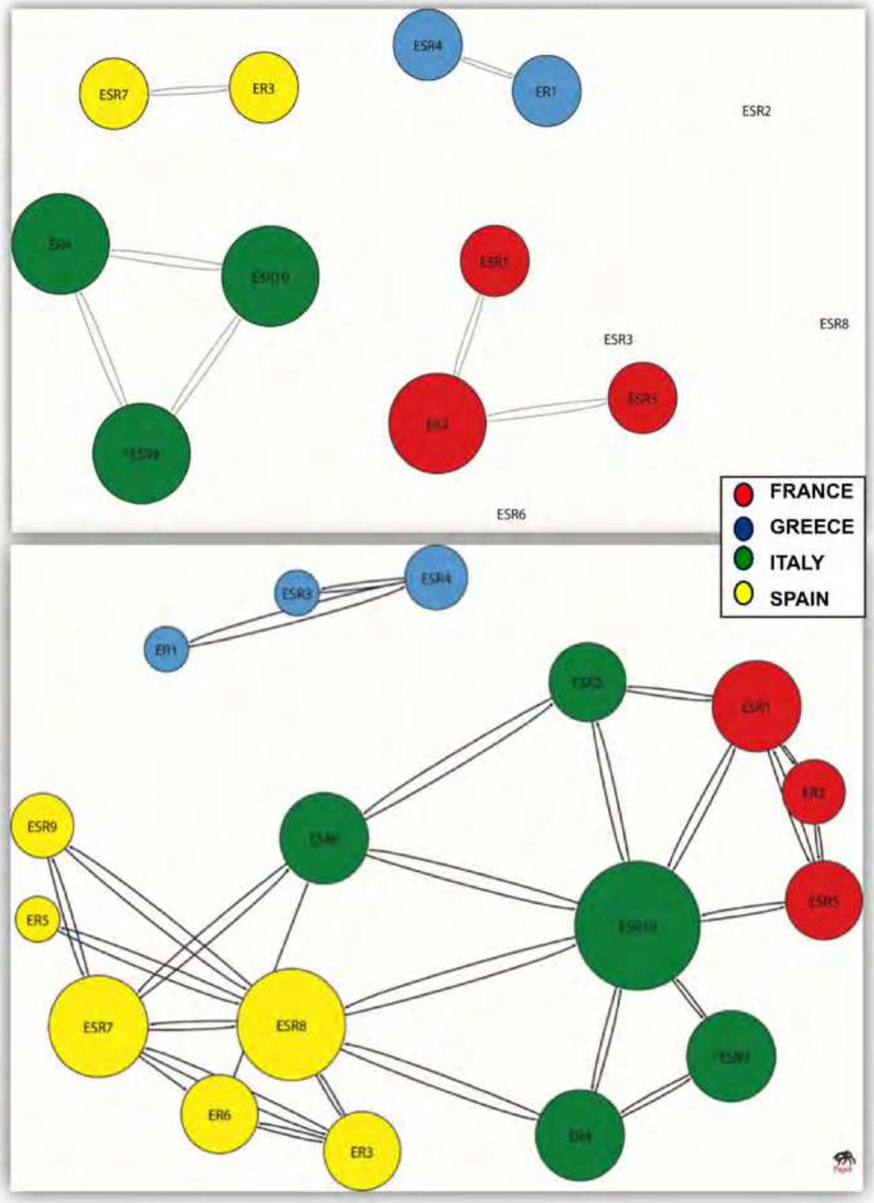

Figure 4. Evolution of MMMPA collaboration network during the project's lifetime. Size of nodes indicates the number of collaborations developed by every Researcher (degree centrality) and colors the fellow's hosting countries with relevant partners

4. Discussion

MMMPA has trained the next generation of MPA managers, equipping them with a flexible set of skills essential within a wide range of professional environments. The project was not only able to deliver tools for effective monitoring, assessment and management actions within the Mediterranean, but has invested in innovative outreach approaches that engage with a much larger public.

The analysis indicates that - although initially fragmented groups were formed in the network - ESRs progressively established connections across individual deliverables and built collaborations through a dynamic process of continuous interaction and communication, which resulted in a cohesive scientific network. A dense network of scientists, managers and decision makers has been created that is expected to spread the project's innovations and results faster. A wide network of young scientists has been born out of MMMPA and it is expected to continue to grow from strength to strength as the fellows continue to collaborate and explore new career perspectives under a shared vision that has been developed for the future resource management in the Mediterranean Sea.

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References

Borgatti, S.P., Everett, M.G., 2006. A graph-theoretic perspective on centrality. Social Networks 28, 466–484.

Wasserman, S., Faust, K., 1994. Social network analysis: methods and applications, second ed. Cambridge University Press, New York and Cambridge.

Monitoring of Mediterranean Marine Protected Areas (MMMPA) project Proposal. Annex I.

Discussion

There is an increasing understanding that the complexity of most ecosystems is matched by equally complex social settings; hence governance aspects, social and ecological systems should be considered together (Ostrom, 1990). Ecosystem-based management (EBM) approaches such as Marine Spatial Planning (MSP) and Integrated Coastal Zone Management (ICZM), require holistic approaches that demand a mechanism for reaching a consensus among multi-sectoral operations and the ecosystem processes, functions, and services (Pomeroy and Douvere, 2008). The use of combined social analysis and participation strategies, along with various forms of information (knowledge, data, ideas and perceptions) is a prerequisite strategy to inform decisions and promote adaptive co-management of marine resources (Markantonatou *et al.*, 2013; Prell, et al., 2009).

In order to promote a holistic approach towards collaboration and effective conservation management in Mediterranean MPAs, the present study aimed to identify the key challenges that currently faced and provide alternative solutions in order to improve MPA management effectiveness. Therefore, the Thesis was initiated with a general exploration of the challenges that currently MPAs face in the Mediterranean basin. This was achieved with the application of a management effectiveness evaluation guide that allowed the identification of issues and prioritize them considering different aspects of management and particular social features (Douvere, 2015; Jones et al., 2011; Tempesta and Otero, 2013). With the growing recognition for the need to move beyond ideological arguments as to which management approach is best, and rather develop governance approaches that combine the steering roles of the state, the market and the people, attention must be given to identifying good practice and its transferability to other MPAs (Jones, 2014). MPA performance needs to be improved in order to halt environmental and socioeconomic decline (Mora and Sale 2011). The outcomes of this work study assisted in understanding the MPA challenges and guided the further focus of the present study in order to suggest new management approaches and tools that will assist towards this direction. More specifically, the management assessment suggested amongst others, to focus towards enhancement of stakeholder engagement and guidance for successful monitoring of socio-economic aspects, such as monitoring of fishing activity.

We focused at Portofino MPA, which is the third smallest MPA in Italy hosting a rich biodiversity and a significant amount of human activities. The relatively small with multiple human activities taking place within the area and opposition of users stimulated by conservation decisions (Salmona and Verardi, 2001), makes Portofino MPA representative of a vast majority of the Mediterranean MPAs. One of the future targets of the MPA's consortium is to expand its area in order to improve its capacity to effectively protect the vulnerable habitats it hosts such as coralligenous. Taking past experience, the lack of adequate communication and up-to-date information in the area into account, this initiative is expected to raise conflict and opposition from users, presenting new challenges in MPA management. This new challenge raises the urgent need for collection of sound information through monitoring; the collation of existing information and local knowledge; comprehensive and structured analysis to provide alternative solutions for the mitigation of human impacts and the achievement of conservation objectives and guide to management decisions (Tempesta and Otero, 2013). Moreover, a transparent and democratic stakeholder engagement process needs to be initiated (Prell et al., 2008; 2009).

Stakeholder engagement promotes transparency and cooperation in decision-making, enhances mutual understanding and assists in the mitigation of conflicts and exploration of possible solutions on the use of marine resources (Pomeroy and Douvere, 2008). However, participation is a complicated and difficult process involving expensive and time-consuming procedures that often results in a limited audience and restricted engagement potential (Reed et al., 2008). The heterogeneity of groups and the emergence of personal interests may pose conflicts or power inequalities capable of influencing perceptions and decreasing the efficiency of policy interventions (Prell et al., 2009). Managers need to involve diverse groups that represent all users' perspectives and interests in a participatory approach that is in line with existing local plans affecting the area at a broader scale (Tempesta and Otero, 2013).

Successful stakeholder engagement is not always straightforward but depends on building reliable social networks that will assure horizontal and vertical communication between resource users and government authorities (Prell et al., 2008). Stakeholder participation has been characterized as a long and difficult process that requires an in depth knowledge of the social-ecological systems' complexity, focusing on the factors that influence stakeholder engagement and the level of participation that is desired. In addition, integration of information and communication strategies that allow interaction and knowledge sharing between users should be considered as the means to achieve successful engagement (Markantonatou et al., 2016).

A core-periphery structure characterizes the Portofino MPA's social network. The core represents the most central stakeholders that pull together the system acting as central hubs in Portofino MPA's social network (Borgatti and Everett, 1999). These core actors combine central characteristics of trusted leaders and brokers with a great potential to promote the initiative of Portofino MPA enlargement (Semitiel-García and Noguera-Méndez, 2012. However, tourism and recreational sectors are predominant user categories that are currently less involved and therefore have limited access to information and resources. Moreover, the fact that the core relies on a few strongly linked actors makes the system vulnerable if these actors dysfunction or were to become inactive (Bodin and Crona, 2009).

To increase participation in Portofino MPA strengthening of weak ties is necessary in order to support the central hubs to widespread information and balance power disparities of core members to control information or circulate exclusively between them (Borgatti and Everett, 2009). Weak ties make the social network more cohesive and create the communication channels from where information may flow more readily reaching marginalized stakeholders (Carlsson and Berkes, 2005; Granovetter, 1973). The fact that most stakeholders desire to actively participate and take responsibilities in the MPA management, and being familiar with the web, provides an important opportunity for the Portofino MPA managers to create the key conditions by combining personal and web technologies for sound governance processes and adaptive management of marine resources (Markantonatou et al., 2016). The present study employed a social network perspective in exploring the governance conditions and their implications in information flow that drive stakeholder engagement in natural resource management. The approach consists of two powerful tools that have been very recently identified in resource management, Stakeholder Analysis and Social Network Analysis that assist conservation managers and planners to explore alternative forms of dynamic stakeholder participation and collaborative management, taking into account restrictions of time, budgetary constraints and availability of stakeholders to participate with their physical presence (Prell et al., 2008; 2009).

Additionally, the present study collected and mapped information relevant to the socio-economic parameters that take place within Portofino MPA. An integrated approach that assesses the pressures and impacts from human activities such as artisanal and recreational fishing activity on vulnerable habitats through a standardized protocol was applied in order to support sound management decisions. The vulnerability and the cumulative impact assessments have revealed that nets, and particularly trammel and combined nets, had the most impact on fishing gears in a coralligenous habitat. The multi-perspective and relatively high level threats that artisanal fishing poses to coralligenous habitats makes these techniques the most destructive practices amongst the ones examined. The weighting anthropogenic drivers by their estimated ecological impact resulted in identification of new potentially areas that are subject to high pressures, in comparison to simply mapping the footprints of human activities (Halpern et al., 2007; 2008). Results showed that areas located between depths of 40-60 m receive the highest fishing pressure, with particular reference to depths of 30-40 m at zone B. The suggested method takes into account the heterogeneity of techniques and captures the different scale of impacts on benthic habitats in a systematic way, providing a useful tool that integrates ecological, management and policy interventions.

There is an urgent need to manage destructive fishing activities in Portofino MPA. Regulations that are currently set by the MPA showed to be inadequate for mitigating the fisheries impact on coralligenous within the MPA. Our results support the review and strengthening of permit conditions towards limitation of fishing activity to restrict benthic impacts (Markantonatou et al., 2014). A possible solution could be the allowance of recreational fishing only during the weekends, or prohibition of destructive fishing practices such as vertical jigging and bottom trolling. Strict mitigation of artisanal nets and bottom longlines is also necessary. Spatial and/or temporal closures after the summer period in the vulnerable areas identified from the cumulative impact analysis are suggested, particularly in the case of increased temperatures this action is expected to limit the likelihood of a massive mortality event on coralligenous (Markantonatou et al., 2015). Aspects such as inspection, the degree to which recreational fishermen accept and comply with the rules and also the economic resources available are key elements in the effectiveness of each MPA (Font et al., 2012). Additional management measures may be applied to strengthen management response, such as consistent retrieval and labeling of gears, organization of regular meetings, promotion of awareness and trust-bonded relations with fishermen (Markantonatou et al., in prep.).

Further analysis on the susceptibility of benthic habitats to lost fishing gear is in accordance with the results produced by the pressure-impact assessment, and the final map was able to capture the most vulnerable parts of coralligenous habitats. The high variation of the area's sea bottom topography in combination to high complexity discriminated all the vulnerable areas in zone B and C that may easier accumulate lost fishing gear. Highly complex areas either due to sea bottom morphology or the presence of complex structural organisms such as sponges, gorgonians and corals also tend to accumulate more gears than less rouged areas. However, in extreme values of seafloor characteristics such as slope that signifies vertical walls, we noticed that there is a clear threshold where the gravity of the gears (nets) becomes the dominant factor acting on the gears to pull them down the sea bottom. Shallower parts of the MPA seem to be more susceptible to the threat from lost gears probably due to the increased activity closer to the coastline. Resultant maps provide geo-referenced information that may assist MPA managers to easily monitor and manage these areas in order to avoid long-term impacts on vulnerable habitats and the sea bottom. By utilizing volunteer divers and sending them directly to those identified points, it is expected to secure a more cost-effective method to monitor and retrieve gears. It is strongly suggested to enforce of fishing gear marking (labeling with an owner name), and education of fishermen in order to notify cases of gear loss. Labeling may ensure that incidents of lost fishing gear will be reported rapidly and appropriate deposition of the gear will take place preventing further impact on benthic organisms. Port reception facilities for old fishing gear may also help to reduce the incidence of lost gears on the seabed and provide data on location and type (Gilman et al., 2015). The fact that this method is applicable to all coastal MPAs even in data poor areas makes this work of extreme importance in order to guide targeted monitoring and retrieval of lost fishing gear by divers (Markantonatou et al., in prep).

After the designing of an interactive baseline for a successful stakeholder engagement, the collection of updated information and the conduction of proper analysis that indicates the areas that are under threats from human pressures, flexible conservation solutions in Portofino MPA were suggested based on information produced. A multiple conservation zoning should be planned where compatible human activities and potential biodiversity threats are managed within specified areas or '*zones*' (Agardy, 2010; Mazor et al., 2014). The application of Marxan With Zones provided systematic conservation planning solutions relevant to the area's expansion and the re-establishment of zoning plans in order to reach conservation objectives with the lowest operational cost (Roberts et al., 2003). High ecological targets were set, accounting also the sustainability of the local economy and sustainable activities practiced within the MPA, suggesting the complementarity of the system's social and ecological drivers for successful MPA management of marine resources. The outcomes of the analysis suggested that the expansion of the MPA is inevitable in order to reach its conservation targets. The preliminary results of the analysis suggest a 4-zones plan, including the enlargement of the no-take zone and the creation of a zone almost completely dedicated to the diving activity that may function as a second reserve in the MPA. The success of the plan to configure the zones in space lies in the fact that the selected areas were popular in the relevant user groups. Most popular fishing grounds of artisanal fishing have been sustained in the new zoning plan, however some limitation exists in the south-western part of the MPA. Recreational fishing is almost completely excluded from the spatial design indicating that the area is too small to keep a balance between all those activities and the rich diversity components it contains.

The outcomes of the whole Thesis revealed significant gaps in existing management plans and highlighted the need for improved management response in Portofino MPA. Jones (2011) highlighted the importance of guaranteeing that top-down approaches should be in balance with bottom-up approaches in order to ensure that a sufficient degree of state exists to support the governance of the MPA providing the legal and economical benefits, but at the same time involving and empowering local actors in deliberations and decisions should take place to achieve decentralized decision-making processes (Bodin et al., 2006).

We highly recommend that the conservation initiative in Portofino MPA should be initiated with the identification and involvement of stakeholders as suggested in Markantonatou et al. (2016). Results should be presented and discussed in a future stakeholder engagement process and integrate the stakeholders' perspective in the analysis (Pomeroy and Douvere, 2008). Many conservation initiatives have failed because they pay inadequate attention to the preferences, interests and characteristics of stakeholders therefore this aspect should not be neglected from the MPA management board (Prell et al., 2009).

Regular meetings, awareness and trust-bonded relations with users are expected to improve the quality of monitoring and sound governance of marine resources. It is also important to highlight that the conservation planning is a continuous adaptive process that requires after the implementation of decisions, to ensure its persistence through monitoring, patrolling and law enforcement (Margules and Pressey, 2000). Ecosystem based approaches such as Marine Spatial Planning (MSP) have been identified as mechanisms that derive maximized long-term ecological benefits and socio-economic welfare in an area (Clarke and Jupiter, 2010). Finally, the fact that Portofino represents a typical case of an MPA where decisions usually stimulate opposition from users makes this methodology and results applicable to MPAs of similar context, and suggests the most updated innovative methods to be applied in order to inform holistically management decisions.

References

Agardy, T., 2010. Ocean Zoning: Making Marine Management More Effective. London: Earthscan.

Bodin, Ö., Crona, B.I., 2009. The role of social networks in natural resource governance: what relational patterns make a difference? Global Environmental Change 19, 366–374.

Bodin, Ö., Crona, B.I., Ernstson, H., 2006. Social networks in natural resource management: what is there to learn from a structural perspective? Ecology and Society 11, r2.[online] URL: http://www.ecologyandsociety.org/vol11/iss2/resp2/

Borgatti, S.P., Mehra, A., Brass, D.J., Labianca, G.J., 2009. Network analysis in the social sciences. Science 323, 892–895.

Borgatti, S.P., Everett, M.G., 1999. Models of core/periphery structures. Social Networks 21, 375–395.

Carlsson, L., Berkes, F., 2005. Co-management: concepts and methodological implications. Journal of Environmental Management 75, 65–76.

Clarke, P., Jupiter, S., 2010. Principles and practice of ecosystem-based management: a guide for conservation practitioners in the tropical western pacific. Wildlife Conservation Society. Suva, Fiji

Douvere, F., 2015. World Heritage Marine Sites. Managing effectively the world's most iconic Marine Protected Areas, UNESCO World Heritage Centre.

Font, T., Lloret, J., Piante, C., 2012. Recreational fishing within Marine Protected Areas in the Mediterranean. MedPAN North Project WWF France.

Gilman, E., 2015. Status of international monitoring and management of abandoned, lost and discarded fishing gear and ghost fishing. Marine Policy 60, 225–239. doi:10.1016/j.marpol.2015.06.016

Granovetter, M., 1973. The strength of weak ties. American Journal of Sociology 78, 1360–1380.

Grieve, C., Brady, D.C., Polet, H., 2014. Best practices for managing, measuring and mitigating the benthic impacts of fishing. Marine Stewardship Council Science Series 2,

18–88.
Halpern, B.S., SELKOE, K.A., Micheli, F., KAPPEL, C.V., 2007. Evaluating and ranking the vulnerability of global marine ecosystems to anthropogenic threats. Conservation Biology 21, 1301–1315. doi:10.1111/j.1523-1739.2007.00752.x
Halpern, B.S., Walbridge, S., SELKOE, K.A., KAPPEL, C.V., Micheli, F., D'Agrosa, C., Bruno, J.F., Casey, K.S., Ebert, C., Fox, H.E., Fujita, R., Heinemann, D., Lenihan, H.S., Madin, E.M.P., Perry, M.T., Selig, E.R., Spalding, M., Steneck, R., Watson, R., 2008. A global map of human impact on marine ecosystems. Science 319, 948–952. doi:10.1126/science.1149345
Jones, P.J.S., 2011. The Wash & North Norfolk Coast European Marine Site–governance analysis. in PJS Jones, W Qiu and EM De Santo (Eds) Governing Marine Protected Areas: getting the balance right - Volume 2. Technical Report to Marine & Coastal Ecosystems Branch, UNEP, Nairobi, 40-59pp.
Jones, P.J.S., 2014. Governing Marine Protected Areas : Resilience Through Diversity, 1st ed. Routledge, Oxon.
Mora, C., Sale, P.F., 2011. Ongoing global biodiversity loss and the need to move beyond protected areas: a review of the technical and practical shortcomings of protected areas on land and sea. Mar. Ecol. Prog. Ser. 434, 251–266. doi:10.3354/meps09214
Margules, C.R., Pressey, R.L., 2000. Systematic conservation planning. Nature 405, 243–253. doi:10.1038/35012251
Markantonatou, V., Marconi, M., Cerrano, C. Susceptibility assessment of seafloor to lost fishing gear in data poor areas in prep.
Markantonatou V, Noguera P, Semitiel-Garcia M, Hogg, K, Sano M, 2016. Social networks and information flow: building the ground for collaborative marine conservation planning in Portofino Marine Protected Area (MPA). Journal of Ocean and Coastal Management, 120: 29-38
Markantonatou, V., Marconi, M., Cerrano, C., 2015. Guidelines for monitoring pressure and impacts from small scale and recreational fishing activity in Mediterranean Marine Protected Areas, Deliverable ITN MMMPA Project, Ancona.
Markantonatou, V., Marconi, M., Cappanera, V., Campodonico, P., Bavestrello, A., Cattaneo-Vietti, R., Papadopoulou, N., Smith, C., Cerrano, C., 2014. Spatial allocation of fishing activity on coralligenous habitats in Portofino MPA (Liguria, Italy), in: Bouafif, C., Langar, H., Ouerghi, A. (Eds.). Presented at the UNEP/MAP- RAC/SPA, Proceedings of the second Mediterranean Symposium on the conservation of Coralligenous and other Calcareous Bio-Concretions. Portorož, Slovenia, 29-30 October 2014, Portorož, Slovenia, pp. 118–123.
Markantonatou, V., Meidinger, M., Sano, M., Oikonomou, E., di Carlo, G., Palma, M., Ponti, M., Cerrano, C., 2013. Stakeholder participation and the use of web technology for MPA management. Advances in Oceanography and Limnology 4, 260–276.
Mazor, T., Possingham, H.P., Edelist, D., Brokovich, E., Kark, S., 2014. The crowded sea: Incorporating multiple marine activities in conservation plans can significantly alter spatial priorities. PLoS ONE 9, e104489. doi:10.1371/journal.pone.0104489
Ostrom, E., 1990. Governing the commons, Cambridge University Press, Cambridge.
Prell, C., Hubacek, K., Quinn, C.H., Reed, M.S., 2008. "Who's in the network?" When stakeholders influence data analysis. Systemic Practice and Action Research 21, 443–458.
Prell, C., Hubacek, K., Reed, M.S., 2009. Stakeholder analysis and social network analysis in natural resource management. Society and Natural Resources 22, 501–518.
Pomeroy, R., Douvere, F., 2008. The engagement of stakeholders in the marine spatial planning process. Marine Policy 32, 816–822.
Reed, M.S., 2008. Stakeholder participation for environmental management: a literature review. Biological Conservation 141, 2417–2431.
Roberts, C.M., Branch, G., Bustamante, R.H., 2003. Application of ecological criteria in selecting marine reserves and developing reserve networks. Ecological … 13, 215–228. doi:10.1890/1051-0761(2003)013[0215:AOECIS]2.0.CO;2

Salmona, P., Verardi, D., 2001. The marine protected area of Portofino, Italy: a difficult balance. Ocean and Coastal Management 44, 39–60.

Semitiel-García, M., Noguera-Méndez, P., 2012. The structure of inter-industry systems and the diffusion of innovations: the case of Spain. Technological Forecasting and Social Change 79, 1548–1567.

Tempesta, M., Otero, M., 2013. Guide for quick evaluation of management in Mediterranean MPAs 1–35.

Conclusions

- A holistic methodological approach was adopted in order to ensure that all the ecological and socio-economic aspects have been integrated to provide efficient management guidance.
- The Mediterranean Marine Protected Areas still encounter various essential management problems relevant to financial, legislature, governance and monitoring issues. An updated guide for assessing MPA management effectiveness was provided with new performance indicators corresponding to a wide variety of management aspects that may assist managers to prioritize and address issues by setting new targets directly linked to management actions. The study identified good examples from in total 17 case studies examined in the Mediterranean suggesting win-to-win examples implemented in MPAs.
- Focused research was applied on Portofino MPA to test the new methodologies suggested in order to provide applicable management suggestions.
- An engagement process was carefully designed and integration of updated and efficient information that was collected during the study. To increase participation in Portofino MPA strengthening of weak ties is necessary in order to support the central hubs to widespread information and balance power disparities of core members to control information or circulate exclusively between them. Integration of peripheral actors in MPA management in order to support information to flow more readily and to add cohesion into the network, supporting the core actors to promote the conservation initiative, to collect information and lead change by using their power, prominence and widespread contacts. Boosting information and knowledge exchange through different communication channels can be achieved by combining personal and web technologies, taking advantage of the preferences of actors regarding the means to communicate.
- The study has suggested relevant guidelines that highlight the capacity of network perspective in exploring the social conditions and their implications in marine resource management. Stakeholder Analysis and Social Network Analysis are complementary methodologies that provide information and guidance for fostering communication, trust and collective learning in natural resource management by minimizing the effort and risks of management success.

● Decision Support Tools relevant to benthic habitat impacts from fishing and systematic conservation planning were used to holistically inform decisions regarding the good status of marine ecosystems to be in balance with human pressures. We have suggested a combination of vulnerability and cumulative impact assessment that integrate ecological, management and policy interventions. The method translates the pressures from fishing into ecosystem specific impacts through vulnerability scores that are assessed using quantifiable attributes of fishing practices as surrogates for the different impacts. The advantage of these tools lays on the fact that they integrate sound ecological and socio-economic information by examining the linkages between ecosystem components, pressures and impacts; they may be easily applied and communicated by managers in a straightforward way

- Results highlighted the need for strict mitigation of artisanal nets and bottom longlines. Spatial and/or temporal closures after the summer period in the vulnerable areas identified from the cumulative impact analysis are suggested, particularly in the case of increased temperatures this action is expected to limit the likelihood of a massive mortality event on coralligenous. Monitoring of human activity using advanced technology may provide accurate information on the catch, by-catch and discards of these practices and thus assure better quality of spatial assessments and effective management response.
- The study of a pressure footprint is not enough alone to provide efficient management guidance for mitigating impacts. We highly recommend that the vulnerability and cumulative impact assessment is also necessary to deliver holistic assessment and accurate evaluation of threats. Outcomes should be deliberated with stakeholders that can make an important contribution by providing expert judgment, fishery-specific and ecological knowledge, and process and outcome ownership. Managers may benefit by the evaluation of the degree to which human activities interfere with the achievement of management objectives, and improve the structure and focus their efforts into more targeted conservation strategies.
- The approach provides a holistic monitoring and assessment for the understanding the spatial and temporal distribution of fishing activity and its potential impacts on vulnerable coastal habitats such as coralligenous. The innovation of the method has prompted the establishment of relevant guidelines that may secure long-term, sustainable fisheries from an ecological and socio-economic point of view and

good ecological status of marine habitats. The framework combines relatively low cost methods that can be progressively evolve along with the MPA management capacity, and is applicable to other ecosystems at any location. The resulting information has the capacity provide baseline information for the identification of metiérs, ecological modelling, stock assessments and conservation planning.

- Lost fishing gear is an important threat on the benthic habitats of Portofino MPA. In order to identify areas that are potentially susceptible to LFG we applied a semi-quantitative spatial analysis using information provided by volunteer divers in the Portofino MPA. The areas that seem to be more susceptible in accumulating lost fishing gear considering sea bottom morphology and fishing activity as driving components overlapped significantly with the results from the vulnerability assessment. The produced map may assist managers, divers and scientists in providing accurate information that will guide monitoring and retrieval of lost fishing gear.
- Systematic Conservation Planning approach indicated that the Portofino MPA's current zonation lacks of effective protection of marine resources. Marxan With Zones was used to suggest a 4-zone scenario for the MPA with which high conservation targets may be reached with the least operational cost.
- Marxan and Marxan With Zones are two powerful tools for conservation planning that allow systematic and transparent selection methods for locating areas to conserve integrating a combination of characteristics, and may solve the most complicated spatial problems in an area. Therefore they should be considered during an MPA establishment the MPA establishment to support direct and targeted conservation strategy. When applied subsequently to the MPA establishment, Marzan With Zones may reveal significant gaps in existing management plans and improve them significantly.

Università Politecnica delle Marche

Dipartimento Scienze Vita e Ambiente

PhD Thesis

“Ecosystem-based management approaches applied to Mediterranean Marine Protected Areas (MPAs): a holistic strategy of governance, ecological assessments and conservation planning in order to inform sound management of marine resources”

Appendices

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Scientific publications

I. Scientific publications (2012-2015)

1. Markantonatou V, Noguera P, Semitiel-Garcia M, Hogg, K, Sano M, 2016. Social networks and information flow: building the ground for collaborative marine conservation planning in Portofino Marine Protected Area (MPA). Journal of Ocean and Coastal Management, 120: 29-38
2. Markantonatou V, Marconi M, Cappanera V, Campodonico P, Bavestrello A, Cattaneo-Vietti R, Papadopoulou KN, Smith C and Cerrano C, 2014. Spatial allocation of fishing activity on coralligenous habitats in Portofino MPA (Liguria, Italy). 2nd Mediterranean Symposium on the conservation of coralligenous and other calcareous bio-constructions, 29-30 October 2014, Portoroz, Slovenia.
3. Markantonatou V., Sano M., Cerrano C. (2013c). Stakeholders, Technology and MPAs: Towards Integrated Management? Proceedings of the Global Congress on ICM (EMECS 10 -MEDCOAST 2013): Lessons Learned to Address New Challenges, 30 October - 03 November 2013, Marmaris, Turkey
4. Meidinger M., Markantonatou V., Sano M., Palma M., Ponti M. (2013b). Seafloor mapping and cartography for the management of Marine Protected Areas. Advances in Oceanography and Limnology.
5. Markantonatou V, Meidinger M, Sano M, Palma M, Ponti M, Cerrano C, 2013. Stakeholder participation and the use of web technology for marine conservation. Advances in Oceanography and Limnology, 4:2, 260-276, DOI: 10.1080/19475721.2013.851117
6. Markantonatou V, Marconi M, Cerrano C, 2016. Guidelines for monitoring pressure and impacts from small scale and recreational fishing activity in Mediterranean Marine Protected Areas. pp 26-37. In: MMMPA Supervisory Board (Eds) Monitoring Mediterranean Marine Protected Areas: A set of guidelines to support the development of management plans. Deliverable of the MMMPA European project (FP7-PEOPLE-2011-ITN g.a. no.: 290056). Ancona, 116p.
7. Markantonatou V, Noguera-Méndez P, Semitiel-García M, Hogg, K, Sano M, 2016. Guidelines for increasing information flow and stakeholder engagement in Marine Protected Areas. pp 98-107. In: MMMPA Supervisory Board (Eds) Monitoring Mediterranean Marine Protected Areas: A set of guidelines to support the development of management plans. Deliverable of the MMMPA European project (FP7-PEOPLE-2011-ITN g.a. no.: 290056). Ancona, 116 p.

II. Publications in progress

1. Markantonatou, V., Marconi, M., Papadopoulou, N., Smith, C., Cerrano, C. Pressure-risk assessment of fishing activity on coralligenous habitats. In preparation.

2. Markantonatou, V., Marconi, M., Cerrano, C. Susceptibility assessment of seafloor to lost fishing gear in data poor areas. In preparation.
3. Markantonatou, V., Milanese, M., Cerrano, C. Monitoring collaboration and integration in scientific projects. In preparation.
4. Prato, G., Barrier, C., Francour, P., Markantonatou, V., Cappanera, V., Guidetti, P., Cattaneo-Vietti, R., Mangialajo, L., Gascuel, D., in prep. A trophic modelling approach to assess artisanal and recreational fisheries impacts and conflicts in MPAs. In preparation.

III. Scientific reports

1. Markantonatou, V., Giakoumi, S., Mazor, T., Gianni, F., Zapata P., Cerrano, C., 2015. Conservation planning in Portofino MPA.
2. Markantonatou, V., 2015. MPA management evaluation in Mediterranean Marine Protected Areas (MPAs). Report on assessment of MPA management effectiveness in the Mediterranean. Report. ITN MMMPA Deliverable. 52pp.
3. Markantonatou et al., 2015. Guidelines for increasing information flow and stakeholder engagement in Marine Protected Areas. Report. ITN MMMPA Deliverable. 9pp.
4. Markantonatou et al., 2015. Guidelines for monitoring fishing activity in Mediterranean MPAs. Report. ITN MMMPA Deliverable. 11pp
5. Markantonatou et al., 2015. The ITN MMMPA experience and networking. Contribution to ITN MMMPA Project Final Report. 7pp.

CASE STUDY 1

PORTOFINO MPA, *LIGURIAN SEA, ITALY*

Background

Portofino MPA (PTF) was established in 1999 under the Ministerial Decree of 26 April 1999, and is one of the smallest MPAs in Italy (total surface 346ha). The objectives of PTF are (i) the protection of the marine environment; (ii) the regulation, promotion and control of fishing activities; (iii) protection and enhancement of biological resources and geomorphological characteristics of the area; (iv) publication and dissemination of knowledge of marine and coastal environments; (v) carrying out educational programs related to ecology, biology and marine geology; (vi) implementation of programs and scientific research in order to ensure the systematic knowledge of the area; (vii) promotion of socio-economic development through the enhancement of existing traditional activities and the creation of new activities compatible with environment.

LEGISLATION AND MANAGEMENT

Adequate legislation on MPAs

- Specially Protected Area of Mediterranean Importance (SPAMI, 2005)
- NATURA2000 network
- Part of Pelagos Sanctuary for Mediterranean Marine Mammals Agreement (1999)
- LTER site (Long Term Ecological Research) of national and international importance (2007)
- Under the authority of the Ministry of Environment.
- Coastal Plan established by the Ligurian Region

Functional management body

- Management Consortium assembled by the three municipalities of S. Margherita L., Camogli and Portofino, the Province of Genova and the University of Genova.
- Responsible for administration, conservation management activities, maintenance, public use and surveillance activities

Updated management plan

- Management plan defines the authority, responsibilities, and regulates activities in the MPA
- Action plan links operational objectives with short-term actions and is updated every year

Financial resources allocated

- PTF receives annual funding from the Ministry based on specific indicators that each MPA in Italy is evaluated; extra 4-year funding in 2013 for monitoring
- Funding is progressively decreasing (decrease with 40% compared to the budget in 2008),
- Participation in several projects in order to cover staff salaries

Patrolling and regulation enforcement

- Responsible authority: Coastguard (national agreement with the Ministry); seasonal (summer) ranger hired that is partially paid by the province of Genova
- MPA personnel cannot enforce the laws in the area
- Maintenance of buoys by a private company; users report the incidents of damages to the MPA or the Coastguard
- Permanent system (6 cameras) placed in key locations linked to the MPA office and the Coastguard.
- Inadequate patrolling particularly during the night and law enforcement could be stricter; some illegal activities take place (boat speed limits, poaching, violation of MPA boarders)

Coordination with stakeholders and planners

- Significant progress regarding stakeholder engagement, through meetings, information and involvement of some actors in projects (e.g. ARION, SUBMED, FLAGS).
- Stakeholder list available
- Stakeholder Analysis and Social Network Analysis (Markantonatou et al., 2015) showed more active participation of some actors is necessary

FEATURES OF INTEREST

Seawater quality (SWQ)

- Seawater quality (SWQ)
- Regional Agency for the Protection of the Environment (ARPAL): collection of abiotic parameters, available to the MPA
- SWQ fully compliant; some pollution incidents have been noticed
- Existence of protocol of pollution emergency from the Coast Guard
- In case of pollution incidents action is taken in collaboration with ARPAL, the University of Genova, the Port Authority, the municipalities and relevant stakeholders

Monitoring of focal habitats and species populations health status

- Every year a new indicator is included in monitoring plan
- Collaborations with Universities, associations (e.g. ReefCheck *italia onlus*), citizen science (divers) and research centres to assist monitoring
- Habitat map developed, SPAMI list of species established
- P. oceanica meadows: Status favourable- locally degraded (coverage and density)
- Coralligenous & focal species: Status favourable (coverage, density); studies on morphology, height, base width, connectivity (e.g. gorgonians and red coral); recovery of the red coral after the intensive past exploitation; some necrosis has been reported in gorgonians due to lost fishing gear and massive mortalities events (e.g. Bavestrello et al., 1997; Cerrano et al., 2006; Cerrano and Bavestrello, 2008; Ponti et al., 2014)
- Cystoseira forests and Carlit index (Gianni, personal communication): general status favourable, locally impacted
- Fish populations: Status favourable – populations increase (Reserve effect measured through underwater visual census (UVC) and list of species established- abundance and biomass; Guidetti et al., 2014); decrease of some species in abundance and/or size (e.g. octopus, lobster) has been reported that resulted in immediate action with new regulations on fisheries in order for the populations to recover

Status of focal physical, cultural and spiritual features

- Positive impact and contribution from MPA existence
- Promotion of culture and tradition: Ziguele association promotes the traditional fishing activity of tonarella; participation of the MPA in events that support tradition and culture such as SlowFood; promotion of aesthetic value of marine habitats and species; improvement of diving sites (e.g. Christo degli Abissi)

Local perception of the MPA

- Information on local perception is not collected regularly, apart from some sporadic studies on diving and recreational boating
- Local community and stakeholders appreciate the benefits and positive effect on their livelihood from the PTF (Markantonatou et al., 2013)

Alternative Livelihoods and/or Income Generating Activities (AL/IGA)

- Information on local perception is not collected regularly, apart from some sporadic studies on diving and recreational boating
- Local community and stakeholders appreciate the benefits and positive effect on their livelihood from the PTF (Markantonatou et al., 2013)

PRESSURES

Monitoring and management of fishing effort

- Since 2011 monitoring is conducted through logbooks and interviews (catch and effort); impact of fishing on fish populations (‘Reserve effect’), occasionally monitoring of prices in the fish market and restaurants
- Status of small-scale fishing is medium-low (24 active fishers), decreasing trend
- Status of recreational fishing is high (around 350 fishers), increasing trend.
- Fishing regulations include spatial closures, gear modifications, closed number of licenses, special limitations for residents and non residents etc., while spearfishing is prohibited.
- Action is taken whenever it is necessary based on monitoring results
- Low quality or no information provided by some fishermen

Monitoring and management of diving activity

- SAbout 28,000 dives (2014) take place in PTF, but can reach up to 40,000
- Monitoring annually number of divers and diving level per diving site
- Current status high, trend slightly decreasing
- Last years diving operators provide less detailed data on the level of divers and/or diving site

Monitoring and management of boating and anchoring

- Monitoring protocol for recreational boating since 2010 (licenses, cameras)
- Total number of recreational boats (2014) around 10,000- on average boats can reach up to 150 boats (weekends during summer), which is considered to be accepted limit with few exceptions of some overcrowded days (Venturini et al., 2015)

Monitoring and management of visitors presence

- Occasionally monitored through questionnaires regarding their marine hobbies and activities in PTF
- Up to 500,000 tourists visit Portofino in the summer months

Action on alien invasive species (AIS)

- Monitoring partial for some species, and through citizen science (MPA web portal, ReefCheck *italia onlus*)
- *Caulerpa sp.* (coverage) - rapid spread from 2007 to the whole zone B
- Collaboration with IUCN on AIS
- Action through awareness projects - mainly target divers

Climate change awareness and actions

- Monitoring sea temperature anomalies, beach erosion and massive mortalities of benthic organisms. However, no standardised monitoring framework has been established
- In 2016 the evaluation of climate change impacts is included in the short-term targets; collaboration with IUCN on global change
- Action through organization of monitoring and awareness events; information through brochures

Action on litter

- Occasional retrieval from sea bottom (lost fishing gear with volunteer divers) and from beach (organized events with volunteers and schools)

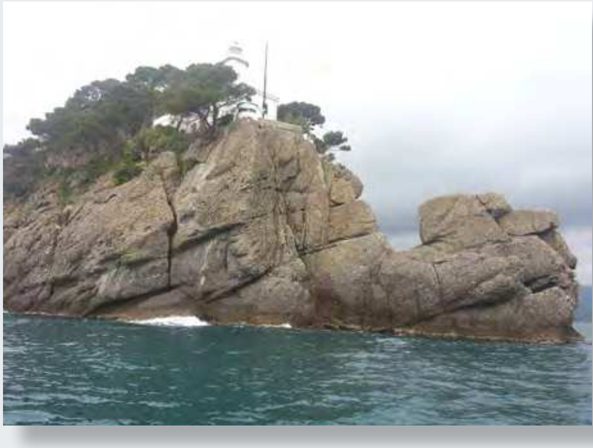
COMMUNICATION & OUTREACH

Existence of outreach activities

- There is no education plan. However, PTF has a range of outreach and communication activities to promote awareness and inform on marine conservation and biodiversity (brochures, reports, press, magazine, social media, web portal, visits to schools, educational projects and notebooks, participation and organization of events etc.)
- Guided tours in PTF are organised by Ziguele association that is also responsible for the museum of Tonnarella in Camogli; Outdoor Portofino is a company carrying sustainable activities such as kayaking, swimming, snorkelling and educational activities

Networking and training

- Training of volunteers and students
- Interaction with MPA network in Italy and Mediterranean (MedPAN), SPAMIs network
- Coordinated action with Pelagos Sanctuary and the relevant MPAs, and international organizations (e.g. WWF, IUCN), scientific and academic centres through projects



ISSUES

1. Need of permanent and trained staff
2. Inadequate funding
3. Partially limited information provided by users
4. Illegal activities, limited patrolling
5. Conflicts between users, and between users and the MPA, along with the importance of tourism in the area hampers decisions and mitigation of activities
6. Limited face-to-face interaction with actors and presence of staff on the field
7. Management of pollution; mitigation of recreational boats and anchoring on *Posidonia oceanica meadows*
8. Inadequate collaboration and legislation inconsistencies between marine and terrestrial part

LESSONS LEARNT

1. Very small surface area of the MPA creates inevitably conflicts between stakeholders and increases pressure on habitats; stakeholder participation is essential
2. Cross-jurisdictional coordination between different administrations of marine and terrestrial part
3. Collaboration with local administrative, scientific institutions and users benefits monitoring and surveillance
4. Sharing of responsibilities and funding between Ministries and local authorities improves quality of MPA management
5. Importance of physical presence on the field in order to promote trust between users and the MPA

REFERENCES

Bavestrello G, Cerrano C, Zanzi D, Cattaneovietti R (1997) Damage by fishing activities in the gorgonian coral *Paramuricea clavata* in the Ligurian Sea. Aquat Conserv 7: 253–262.

Cerrano C, Totti, C, Sponga F, Bavestrello G, 2006. Summer disease in Parazoanthus axinellae (Schmidt, 1862) (Cnidaria, Zoanthidea), Italian Journal of Zoology, 73:4, 355-361, doi:10.1080/11250000600911675

Cerrano C, Bavestrello G, 2008. Medium-term effects of die-off of rocky benthos in the Ligurian Sea. What can we learn from gorgonians? Proceedings of the Scientific Meeting of the V Congress of the National Inter-University Consortium for Marine Sciences (CoNISMa),Viareggio, November 14–18 2006. Chemistry and Ecology, 24(1)

Guidetti, P, Baiata, P., Ballesteros, E., Di Franco, A., Hereu, B., Macpherson, E., Micheli, F., Pais, A., Panzalis, P., Rosenberg, A.A., Zabala, M., Sala, E., 2014. Large-Scale Assessment of Mediterranean Marine Protected Areas Effects on Fish Assemblages. PLoS ONE 9, e91841. doi:10.1371/journal.pone.0091841

Markantonatou V, Sano M, Cerrano C, 2013. Stakeholders, Technology and MPAs: Towards Integrated Management? Proceedings of the Global Congress on ICM (EMECS 10 -MEDCOAST 2013): Lessons Learned to Address New Challenges, 30 October - 03 November 2013, Marmaris, Turkey: 293-304

Ponti M, Perlini RA, Ventra V, Grech D, Abbiati M, Cerrano C, 2014. Ecological Shifts in Mediterranean Coralligenous Assemblages Related to Gorgonian Forest Loss. PLoS ONE 9(7): e102782. doi:10.1371/journal.pone.0102782

Venturini S, Massa F, Castellano M, Costa S, Lavarello, I, Olivari E, Povero P, 2015. Recreational Boating in Ligurian Marine Protected Areas (Italy): A Quantitative Evaluation for a Sustainable Management, J Environmental Management, 1-13, doi: http://dx.doi.org/10.1007/s00267-015-0593-y

KEY INFORMANTS:

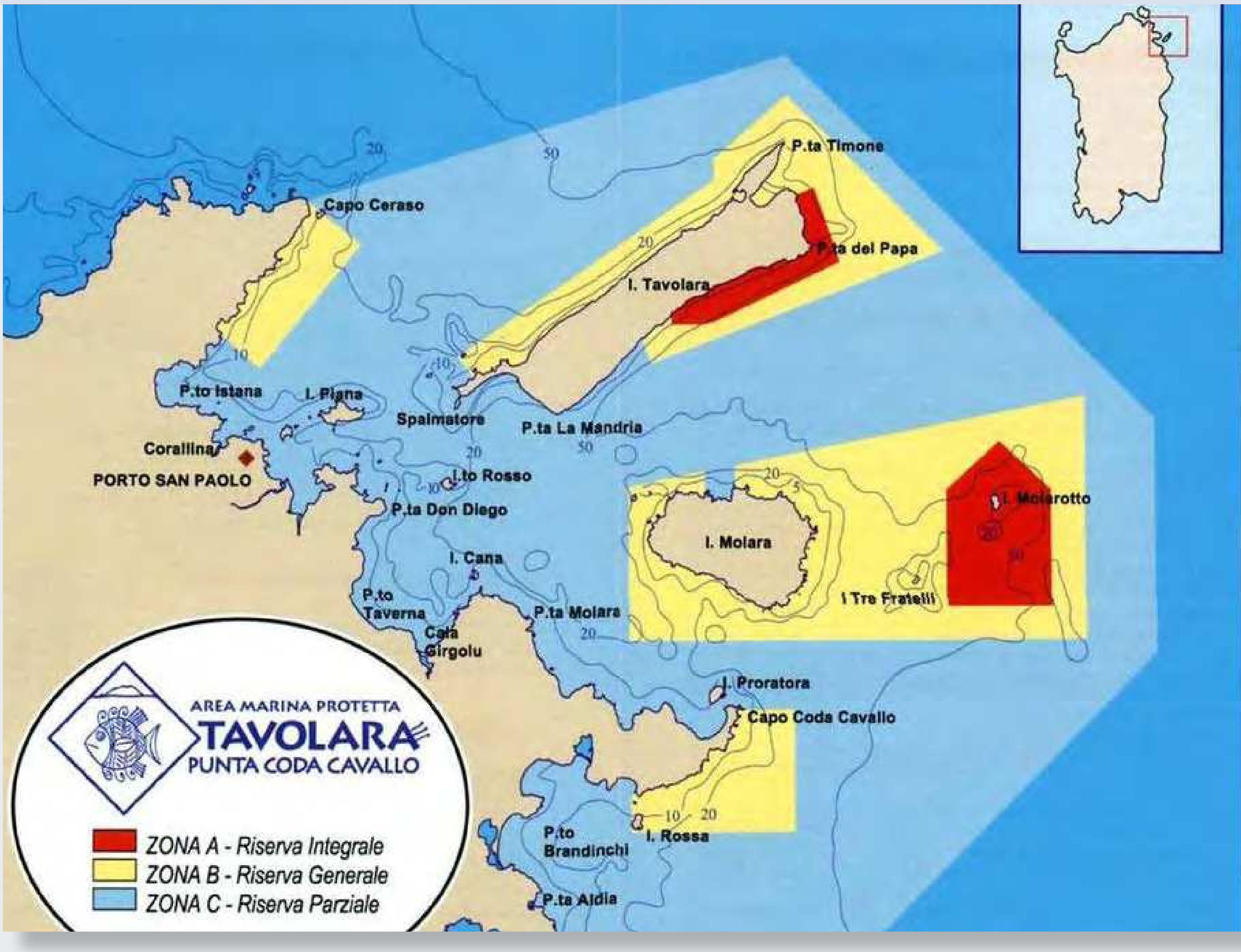
- MPA Director: **Dr. G. Fancioulli**
- MPA staff: **Dr. Cappanera V., Campodonico P.**
- Stakeholders: **divers, professional fishermen**

Individual management assessment for Portofino MPA

YEAR 2015		
Name of the indicator	**Total score**	**additional score**
Existence of legislation on MPAs	1	3
Existence of a functional management body	6	
Existence of a updated management plan	5	
Financial resources allocated to the MPA	2	
Patrol and regulation enforcement	4	2
Seawater quality	1	3
Focal habitats´ conservation condition	F	2
Focal species abundance and population structure	3	4
Management of fishing effort	3	3
Diving	2	3
Boating and anchoring	3	2
Action on alien invasive species	2	1
Existence of outreach activities	6	1
Management of visitors presence	4	2
Networking and training	3	3
Coordination with stakeholders and planners	3	3
Status of focal physical, cultural and spiritual features	B	
Climate change awareness and actions°	7	1
Alternative Livelihoods and/or Income Generating Activities (AL/IGA)	1	1
Local perception of the MPA	3	3
Action on litter	2	2

CASE STUDY 2

TAVOLARA-PUNTA CODA CAVALLO MPA, *SARDINIA, ITALY*



Background

Tavolara - Punta Coda Cavallo MPA (TPCC) was established in 1997 with a Ministerial Decree (GU n. 47 del 26-2-1998). It covers about 15,000 hectares of sea and the coastal territories of the Municipalities of Olbia, Loiri Porto S. Paolo, and San Teodoro. The aims of the MPA is (i) the protection of the marine environment; (ii) the protection and enhancement of biological and geomorphologic resources of the area; (iii) the diffusion and dissemination of knowledge of marine and coastal environments of the area; (iv) carrying out educational programs for the improvement of knowledge; (v) promotion of programs of study and scientific research in order to ensure the systematic knowledge of the area; (vi) the promotion of sustainable socio-economic development compatible with the naturalistic landscape of the area, favouring traditional local activities.

LEGISLATION AND MANAGEMENT

Adequate legislation on MPAs

- SPAMI area
- NATURA2000 site (SCI-IT010011, SPA- IT010011)
- EMAS certification (2005)- a voluntary program established by the European Union enabling organizations to seek certification for their environmental management systems
- At the local level TPCC is a node of Sardinia Regional Network for Marine Fauna Conservation
- Memorandum for the coordination of the CAMP Coast Conservation (Regional decision no 72/16 of the 19/12/2008) by the Region of Sardinia and the Ministry of Environment.

Functional management body

- Management Consortium: the three Municipalities, which is further split into 5 responsible authorities (Assembly; Board of Directors; President; Director and the Board of Auditors). The MPA has qualified and trained staff has specific responsibilities (Directorate operational, Technical Department, Environment office, Environmental Education Office and Communications)

Updated management plan

- Management plan approved in 2006; not frequently updated
- Two management plans (ISEA-MPA by the Ministry of Environment, SCI-NATURA2000 in Sardinia region. Currently TRCC is trying to integrate the two plans in terms of socioeconomic and the environmental aspects.
- Management plan an operational tool that defines the authority, responsibilities, regulates uses to make them compatible with the presence of habitats and species, and identifies concrete targets, measures and conservation actions necessary to maintain and/or restore them (4 axes: environmental framework, socio-economic, management interventions, cartography).
- Action plans (15) have been developed with stakeholders and local community

Financial resources allocated

- Annual funding from the Ministry based on specific indicators that each MPA in Italy is evaluated; extra 4-year funding in 2013 for monitoring
- Funding is progressively decreasing, covers about 40% of the MPA needs
- Additional funds (60% of needs) comes from the local administrations involved in the Management Body and other entities
- Participation in several projects in order to cover staff salaries and several other needs

Patrolling and regulation enforcement

- Responsible authorities: Coastguard through a national agreement with the Ministry and Corp. of forestry of Sardinia region; reporting number of violations to TRCC
- Permanent surveillance system of 4 cameras accessed by the MPA and the coastguard
- High social control (divers, residents, tourists, fishermen) that report violations
- MPA personnel and the Director himself patrol the area but lack enforcement authority; their role is restricted to notification of visitors regarding the regulations of the area
- Some illegal activities during the night due to lack of surveillance (e.g. violations in entering zone A, boat speed limit, illegal fishing, unauthorized mooring, use of jet skis)

Coordination with stakeholders and planners

- The MPA, stakeholders and the local community have developed over 15 plans to address issues where a scientific monitoring component is set
- Stakeholder meetings are frequent, actors participate actively in the MPA decision-making and management; mutual understanding, respect and trust between actors and the TPCC
- Suggestions are heard and sometimes implemented (e.g. information signs, protective fences etc.)
- Common solutions are found (e.g. with beach actors, divers, rental boats, fishermen)

FEATURES OF INTEREST

Seawater quality (SWQ)

- Condition of SWQ favourable
- Responsible: Regional authority (ARPAS) reporting to TPCC
- In case of incident TPCC conducts additional monitoring
- Specific exercises for oil spills and control of pollution in collaboration with the Coastguard, stakeholders and local community
- ECOPORTO project - provided advice regarding the retrieval of ballast waters, oil and bilge water
- Some evidence of impacts from pollution near coastal settlements (e.g. mucilaginous algal blooms - Caronni et al, 2014; 2015; Michelli and Niccolouli, 2013)

Monitoring of focal habitats and species populations health status

- Status of habitats favourable (Michelli and Niccolouli, 2013)
- Updated high accuracy habitat map, performance indicators provide feedback and update regulations, monitoring by the TPCC and through collaborations with academic and research centres
- *P. oceanica*: coverage, density coefficient, lepidochronology, height of leaves (Panzalis et al., 2014
- Coralligenous, necrosis and mortality events (e.g. Bianchi et al., 2007; Ponti et al., 2014; Verzulli et al., 2013)
- Cystoseira forests and CARLIT index (Gianni F., personal communication)
- Sandy beaches and dunes: monitoring through aerial photos has shown great improvement of their status; protection through the creation of paths, prohibition of access to dunes and creation of corridors for visitors, information panels, and projects (ECOCOSTE)
- Calcareous cliffs and granitic formations using innovative approaches and collaborations with academic and research centres
- Lists of key species present in the area (protected - endemic - SPAMI species list; keystone species of vulnerable habitats marine and terrestrial fauna and flora; seabirds (*e.g. Puffinus* -LIFE Project); marine mammals)
- Monitoring of fish populations and protected fish species (e.g. *E. marginatus, S. umbra* etc.) with UVC (biomass/m2 of the fish) in and out the MPA (Guidetti et al., 2014). The total fish biomass in the TPCC is three times greater than the average (total biomass 1.3–31 times greater than other MPAs) of the 14 other Mediterranean MPAs surveyed (Sala et al. 2012). The sea urchin *P. lividus* is also monitored due to its fishing.

Status of focal physical, cultural and spiritual features

- Status increased
- Collaboration of TPCC and agencies taking actions to improve the protection or enhance valuable elements of historical, cultural or traditional features of the area (e.g. in 2011 TRCC and the Archaeology excavated archaeological sites and discovered antiquities in Tavolara Island)
- Participation and organization of events that promote focal features, local culture and tradition

Local perception of the MPA

- Local community recognises the benefits perceived by TPCC regarding their business, the long-term sustainability of their area and are strongly supportive
- Common sustainable vision developed between TPCC, stakeholders and local community
- Study for identifying the importance of social and cultural factors (cultural context analysis)

Alternative Livelihoods and/or Income Generating Activities (AL/IGA)

- Socio-economic studies focused on: (i) the sectors and stakeholders that may affect the ecological condition of the MPA (e.g. coastal development, fishing); (ii) the perceptions, vision and attitudes of different stakeholder groups; (iii) alternative livelihoods of business (e.g. renting and leasing of boats); (iv) identification of the social, demographic, economic, and cultural factors that influence the social and ecological performance of the system
- Monitoring of touristic activity and income of the wider area
- Encouragement of projects and selling of products that promote sustainability
- Some concern from local community due to the use of the same resources with recreational fishers has been reported to the TPCC

PRESSURES

Monitoring and management of fishing effort

- Monitoring of fishing and long-term effects on the fish-stock through CPUE (kg of fish/km of nets; biomass/m2 of the fish), fleet and proportion of fishing gears, on board observers every 2 years
- Currently about 15 small-scale resident fishermen in TPCC, the majority of which (92%) use nets; average catch 25kg/km from all the gears used and about 16kg only with trammel nets
- Small-scale fishing is in line with optimal conservation (minimal impact); Catch is much higher in terms of quantity and quality inside the MPA than outside (e.g. *Mullus surmuletus* caught inside TPCC is sold at a higher price 10% than outside; Di Franco et al., 2009; Panzalis et al., 2014; Pizzolante, 2009; Sala et al., 2012)
- Recreational fishing is not monitored (monitoring will start in 2015 through licenses), except for gathering sea urchins (*P. lividus*). Spearfishing is prohibited.
- Assessed as relevantly high, particularly during summer, and may have an impact on the key habitats; some impacted areas from lost fishing gear (longlines) have been noticed on gorgonians. As a response to the high risk of recreational fishing in the area, a new regulation on 9 January 2015 was gazetted that prohibits trolling, vertical jigging and similar techniques, the removal of *Epinephelous marginatus* and *Sciaena umbra*, and the use of alien species bait (e.g. worm Koreano, Spanish, Japanese)

Monitoring and management of diving activity

- Annual monitoring of diving activity through logbooks (number of divers per diving spot) and during surveillance by TPCC and Coastguard in order to verify data
- Evaluation studies regarding values and risk of the diving sites (services offered to divers; mapping, description and environmental evaluation of the diving spots; touristic value of diving spots; carrying capacity of diving spots; surveys in divers regarding preferences/nationality/cost; environmental impact of CO_2 produced)
- Penalties in diving centers that exceed the carrying capacity of the diving site
- Information to diving operators regarding diving behaviour, the management of diving impact, safety equipment and nautical navigation
- Regular informative meetings and involvement of divers in projects with TPCC

Monitoring and management of boating and anchoring

- About 900 leisure boats, with peaks on high seasons up to 2000 per day
- Monitoring mainly by Coastguard, the MPA during patrolling and by using a small ultra light plane (photos, every two weeks), special authorization (compulsory)
- Studies regarding the environmental and sea bed damage by recreational boats; preferences on beaches and areas through direct interviews
- Jumper mooring buoys and removable floating piers limiting damage on seabed
- Development of smartphone app ('DONIA') – provides digital cartography, information on the presence of vulnerable habitats, environmental impacts from anchoring
- In 2015 within the TPCC plans is to establish a fee for operators and establishment of numeric quota in relation to the carrying capacity of each site

Monitoring and management of visitors presence

- Monitoring of tourism arrivals and departures from the port, beach users, visitors and passenger movements to the Tavolara island (through info points and air photos)
- Studies on the carrying capacity of the islands for visitors
- Tourism and related activities was reported to be the biggest threat

Action on alien invasive species (AIS)

- Low abundances of AIS (Ceccherelli et al. 2006; Sala et al. 2012). However, invasion is increasing in the MPA particularly for *C. racemosa*
- Monitoring of microalgae *Chrysophaeum sp.* inside the MPA (Carroni et al., 2010; 2014; 2015) and *Caulerpa sp.*
- Eradication of *C. taxifolia* using volunteer divers
- Information and increase of awareness on AIS to the public and stakeholders

Climate change awareness and actions

- Monitoring of effects on benthic assemblages (e.g. mass mortalities events), sandy beaches erosion, abiotic factors

Action on litter

- Organization of beach cleaning, sea bottom cleaning with volunteers and local authorities
- Monitoring of litter in collaboration with local authorities
- Information, trash bins in the area, ashtrays provided to visitors

COMMUNICATION & OUTREACH

Existence of outreach activities

- Educational and awareness activities: educational workshops and laboratories; projects with beach activities; introduction in marine life and sea bottom cleaning involving volunteers (e.g. SALVAMARE); variety of brochures; information panels; information points; Museum of the Sea; organized public events (e.g. art festivals as opportunity for engagement and promotion of MPA values); public meetings; week of UNESCO Education for Sustainable Development (workshop regarding recycling and re-use); excursions and educational programs with visitors and schools (collaboration with Social Cooperative 'Axinella'; sea watching (Marine Mammal Research Centre-CRiMM)
- Engage with other centers to exchange knowledge-techniques-methodologies
- Press and media; gadgets; Website and Social Media

Networking and training

- Participates in Conferences for exchange of experience
- Collaboration in projects with experts and organizations from all over the world
- Promotion of certified environmental education centres (CEA) based on the validation as ISO (TPCC leads the network of CEAs in Italy)
- Part of a wide range of MPA networks in Italy and the Mediterranean

ISSUES

1. Limited permanent and experienced personnel
2. National legal framework lacks of management experience and practical elements, mainly administrative target and not conservation, has excluded the bottom up approach
3. Lack of homogenized monitoring indicators in the italian MPAs hampers performance evaluation
4. Budget restrictions in monitoring and MPA demands due to its wide area
5. Anchoring of boats on *P. oceanica* meadows, beach nourishment, invasion of *Caulerpa spp.,* coastal infrastructure and tourism development
6. Illegal activities during the night and lack of law enforcement by MPA

LESSONS LEARNT

1. Bottom up approaches, collaboration, personal interaction and development of management plans and common vision with stakeholders benefit MPA management in general
2. Adoption of innovative technologies assist in monitoring, communication and better understanding of the system
3. MPAs role in education and awareness
4. Carrying capacity and socio-economic studies facilitate management response and benefit sustainable development of local community
5. Coordination of efforts by different authorities secures pro-action and best management performance
6. Collaborations and participation in projects may secure important funds for MPA needs

REFERENCES

Bianchi CN, Cattaneo-Vietti R, Morri C, Navone A, Panzalis P, Orru P, 2007. Coralligenous formations in the Marine Protected Area of Tavolara Punta Coda Cavallo (NE Sardinia, Italy). Biol Mar Mediterr, 14(2):148-149

Caronni, S., Ceccherelli, G., Navone, A., Occhipinti-Ambrogi, A., Panzalis, P., Pinna, S., Sechi, N., 2010. Distribution and density of the benthic microalga Chrysophaeum taylorii Lewis & Bryan from northern to central-eastern Sardinian coasts. Biol. Mar. Mediterr. 17, 292-293

Caronni, S., Delaria, M.A., Navone, A., Panzalis, P., Sechi, N., Ceccherelli, G., 2014. Relevant scales of variability of the benthic allochthonous microalga Chrysophaeum taylorii. Mar. Biol. 161, 1787-1798

Caronni S, Bresciani A, Delaria MA, Meloni F, Navone A, Panzalis, P, Heimann K, Ceccheerelli G, 2015. Ecology of the benthic mucilage-forming microalga Chrysophaeum taylorii in the W Mediterranean Sea: Substratum and depth preferences. Estuarine Coastal and Shelf Science, 161: 38-45

Ceccherelli G, Casu N, Nicola S, 2006. Spatial variation of intertidal assemblages at Tavolara-Capo Coda Cavallo MPA (NE Sardinia): Geographical vs. protection effect. Marine Environmental Research 59(5):533-46

Di Franco A, Busotti S, Navone A, Panzalis P, Guidetti P, 2009. Evaluating effects of total and partial restrictions to fishing on Mediterranean rocky-reef fish assemblages. Mar Ecol Prog Ser, 387: 275–285

Guidetti, P., Baiata, P., Ballesteros, E., Di Franco, A., Hereu, B., Macpherson, E., Micheli, F., Pais, A., Panzalis, P., Rosenberg, A.A., Zabala, M., Sala, E., 2014. Large-Scale Assessment of Mediterranean Marine Protected Areas Effects on Fish Assemblages. PLoS ONE 9, e91841. doi:10.1371/journal.pone.0091841

Huete-Stauffer C, Vielmini I, Palma M, Navone A, Panzalis P, et al. (2011) Paramuricea clavata (Anthozoa, Octocorallia) loss in the Marine Protected Area of Tavolara (Sardinia, Italy) due to a mass mortality event. Mar Ecol Evol Persp 32: 107–116. doi: 10.1111/j.1439-0485.2011.00429.x

Micheli F, Niccolini F, 2013. Achieving Success under Pressure in the Conservation of Intensely Used Coastal Areas. Ecology and Society, 18(4):19. http://dx.doi.org/10.5751/ES-05799-180419

Panzalis P, Caabretti, C, Caronni S, Delaria MA, Navone A, Ceccherelli G, 2014. Characterization of the fish assemblage in a *Posidonia oceanica* meadow invaded by Caulerpa racemosa. Biol. Mar. Mediterr, 21(1):261-262

Ponti M, Perlini RA, Ventra V, Grech D, Abbiati M, Cerrano C, 2014. Ecological Shifts in Mediterranean Coralligenous Assemblages Related to Gorgonian Forest Loss. PLoS ONE 9(7): e102782. doi:10.1371/journal.pone.0102782

Sala E, Ballesteros E, Dendrinos P, Di Franco A, Ferretti F, et al. (2012) The Structure of Mediterranean Rocky Reef Ecosystems across Environmental and Human Gradients, and Conservation Implications. The Structure of Mediterranean Rocky Reef Ecosystems across Environmental and Human Gradients, and Conservation Implications. PLoS ONE 7(2): e32742. doi: 10.1371/journal.pone.0032742

Tavolara Punta Coda Cavallo web portal: www.amptavolara.com

Vezzulli L, Pezzati E, Huete-Stauffer C, Pruzzo C, Cerrano C (2013) 16SrDNA Pyrosequencing of the Mediterranean Gorgonian *Paramuricea clavata* Reveals a Link among Alterations in Bacterial Holobiont Members, Anthropogenic Influence and Disease Outbreaks. PLoS ONE 8(6): e67745. doi:10.1371/journal.pone.0067745

KEY INFORMANTS:

- Director of TPCC **Dr. Augusto Navone**
- MPA staff **Dr. Pieraugusto Panzalis, Dr. Sarah Caronni**

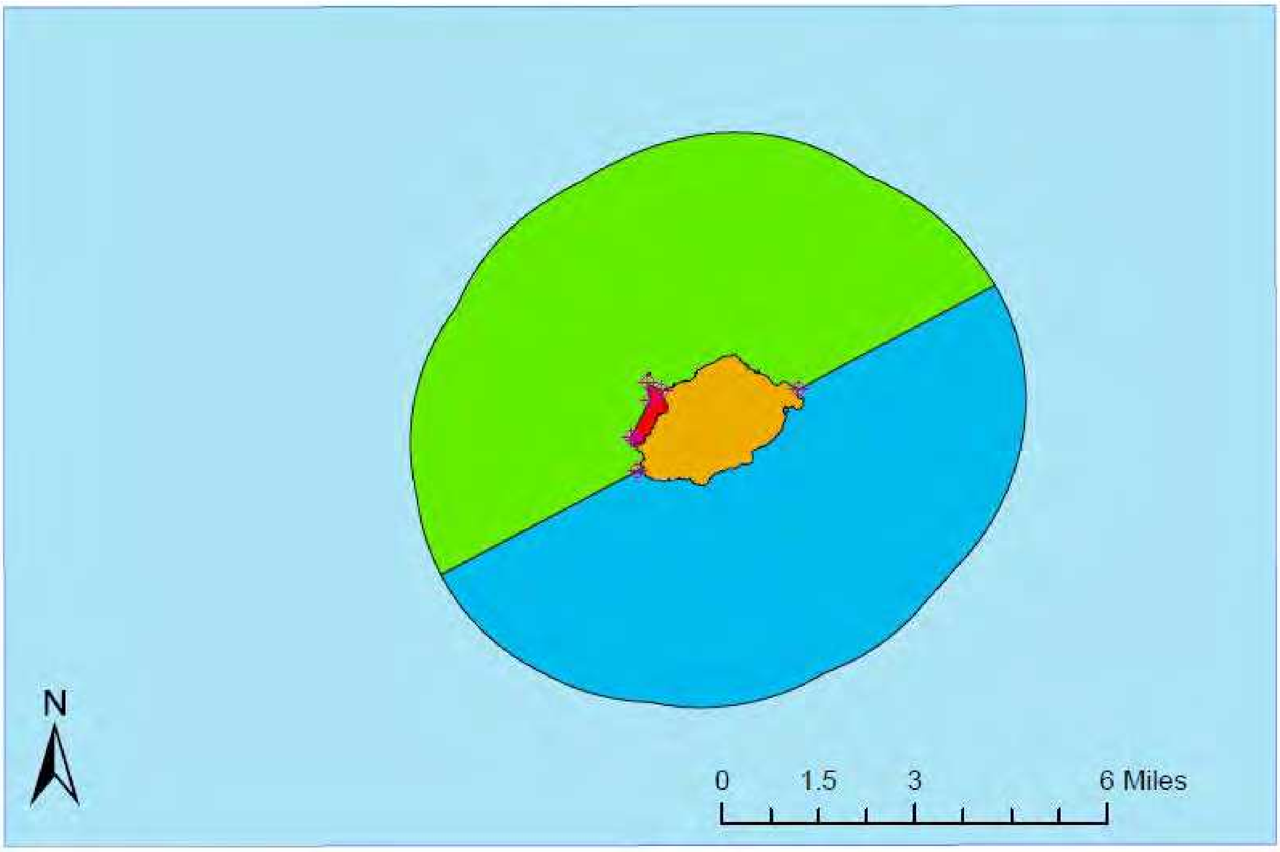
Individual management assessment for Tavolara- Punta Coda Cavallo MPA

YEAR 2014-2015		
Name of the indicator	Total score	additional score
Existence of legislation on MPAs	1	3
Existence of a functional management body	6	
Existence of a updated management plan	4	
Financial resources allocated to the MPA	1	
Patrol and regulation enforcement	6	2
Seawater quality	1	4
Focal habitats´ conservation condition	F	2
Focal species abundance and population structure	4	4
Management of fishing effort	4	3
Diving	4	3
Boating and anchoring	3	2
Action on alien invasive species	2	2
Existence of outreach activities	8	1
Management of visitors presence	6	3
Networking and training	3	3
Coordination with stakeholders and planners	4	4
Status of focal physical, cultural and spiritual features	B	
Climate change awareness and actions°	9	1
Alternative Livelihoods and/or Income Generating Activities (AL/IGA)	2	4
Local perception of the MPA	3	3
Action on litter	2	2

CASE STUDY 3

USTICA MPA, *SICILY, ITALY*

Ustica MPA. Map produced by
V. Markantonatou and UBICA srl.



Background

Ustica MPA (UST1) was established in 1986 (GU n. 71 del 26.03.1987) and is the oldest in Italy, with surface area of 15,951ha. The main objectives are (i) the protection of the marine environment; (ii) the protection and enhancement of biological resources and the restocking of the area; (iii) the dissemination of knowledge of the biology of marine environments, the mineralogical and geomorphological characteristics; (iv) the execution of educational- character programs in the field of marine biology and ecology; (v) the conduction of scientific research programs targeted on marine biology and environmental protection.

LEGISLATION AND MANAGEMENT

Adequate legislation on MPAs

- UST is under the authority of the Ministry of Environment
- Adequate regulatory framework addressing MPAs designation and management criteria specified in the law, but monitoring is not compulsory legally
- No regional plan for ICZM

Functional management body

- Management Board (board of councillors): the Municipal Government and the Council of Ustica, which are responsible for the performance of administration, conservation management, maintenance, public use and surveillance activities
- MPA Director1
- MPA Commission- external Advisory Board comprised by scientific institutions and NGOs, which provides advise on specific documents like the “rule book”, or the annual variation of the rulebook, which is not binding

Updated management plan

- The narration of the “rule book”- includes specific management measures applied within a period of a year; annually evaluated and approved by the Municipality

Financial resources allocated

- The annual funding from the Ministry covers 1/3 of the total MPA needs
- Decreasing trend with important implications in MPA activities and monitoring
- Minor additional income is received by the involvement of the MPA to regional, national and EU projects, and through self-financing (buoys, divers fees, penalties etc.)

Patrolling and regulation enforcement

- Responsible authority: Coastguard (national agreement with Ministry) which has the authority to enforce law and give fines to violators; the MPA is restricted in providing information on regulations but cannot enforce the law
- Patrolling is partial, enforcement is limited and poachers are frequently reported
- UST informs stakeholders and tourists on marine and terrestrial regulations through brochures, maps, info point and personal communication
- There is no boat available for the MPA to patrol

Coordination with stakeholders and planners

- Frequent meetings with local stakeholders (about 10 per year) facilitate building of trust-bond relationships, consensus on decisions that protect biodiversity while allow economic development, and reporting illegal activities
- Collaboration and dialogue between the MPA and stakeholders has resulted several times in mitigation of conflicts or oppositions to MPA decisions (e.g. divers fee)
- Collaboration with terrestrial part and attempts for common action (e.g. establishment of recycling)
- Daily presence of Director on the field and personal interaction with stakeholders

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1. *Information was retrieved in a period that the new Director had just taken over the management of the MPA. Therefore, some information is considered partial since no previous information exists on conservation features and human activities. Due to the latter resigning of the Director, the present study provides information only for the period that Dr. Di Carlo was in charge and cannot guarantee that this information is valid for year 2015.*

2. *Dr. Giuseppe Di Carlo completed his service in 2014 (duration almost 2 years)*

FEATURES OF INTEREST

Seawater quality (SWQ)

- No monitoring of SWQ
- A recent study showed that there is no detectable human influence on the hydrological characteristics, despite the increase in population due to tourism, which is recorded during the summer months (Sanfilippo et al., 2009)

Monitoring of focal habitats and species populations health status

- Status of species and habitats is in general considered favourable, although no previous assessment is done
- Monitoring initiated in 2014 by the new Director initiated, hence no trends could be identified: *P. oceanica* (coverage, density), visual assessment of coralligenous and annual monitoring of key species (i.e. groupers, sponges) through collaborations with academic and scientific centres
- Special agreement with Co.R.I.S. (Cooperativa Ricerche ed Indagini Scientifiche soc. coop.) for monitoring specific aspects of marine biodiversity
- Collaboration with ReefCheck Italia onlus - trained divers to collect lost fishing gear and monitoring targeted to specific vulnerable habitats and species.
- No particular species list is established
- Ustica owns its own marine laboratory located at the Spalmatore Tower, which is currently inactive and there are currently no instruments to support monitoring

Status of focal physical, cultural and spiritual features

- Assessed as stable although no previous assessment is done

Local perception of the MPA

- Local community appreciates the presence of the MPA
- Past experience of local community with previous management was traumatic due to the lack of conservation measures and activities that could support ecological and socio-economic sustainability of the area. Watching progress being made with the new Director has created trust and belief for local economy improvement

Alternative Livelihoods and/or Income Generating Activities (AL/IGA)

- Average population density is 128 residents/km2
- Main population activities are tourism, diving, fishing and agriculture (pears, vines, and vegetables)
- The fact that tourism and fishing stocks have decreased the last years has raised concerns to the local community and stakeholders regarding the resulting drop of their income. Although their expectations are great, they identify and support the MPA's effort to support AL/IGA

PRESSURES

Monitoring and management of fishing effort

- There are about 190 artisanal and recreational fishermen active
- Status estimated as high for artisanal and medium for recreational fishing
- Monitoring and management is made by regulating the number of boats, permits and MPA spatial regulations (zoning). Spearfishing is prohibited.
- No standardized monitoring for fishing landings is established, nor action has been taken so far to reduce fishing pressure

Monitoring and management of diving activity

- Diving pressure has been estimated to be 8000 divers per year, with maximum values during summer, and thus relatively low
- Monitoring and management through the number of authorizations; spatial regulations; restriction on the number of divers per site; logbooks where divers state the number of divers/day/site
- UST informs diving operators regarding diving behaviour underwater
- No studies on carrying capacity per diving site

Monitoring and management of boating and anchoring

- Although monitoring was initiated just in 2014 boating is generally low
- Management and monitoring through authorizations for mooring (released on a daily, weekly and monthly basis), and the fee is compulsory
- Spatial closures and regulations on the type of boats
- Distribution of informative maps with the zoning and regulations to boaters

Monitoring and management of visitors presence

- About 500-600 visitors per year arrive to UST
- Monitoring through the boat companies
- Questionnaires are conducted in the port of the island regarding socio-economic features of visitors
- Status of the impact from tourism is low and the existing infrastructure can support well the visitors' advent
- The majority of visitors are stimulated for diving, but there are also beach users coming mainly from Palermo for the weekend during summer period

Action on alien invasive species (AIS)

- No regular monitoring for invasive species
- Low risk of invasion in the area
- In 2014 a first attempt to record the presence and spread of the tropical Atlantic crab *Percnon gibbesi* took place

Climate change awareness and actions

- No monitoring programme in the MPA to evaluate the physical impacts of climate change

Action on litter

- Organised events with volunteers and MPA staff for litter collection from the beach and sea bottom (lost fishing gear with divers)
- Information and education
- Placement of trash bins and ashtrays at the beaches

COMMUNICATION & OUTREACH

Existence of outreach activities

- Info point: information to visitors for MPA and regulations
- Promotion of local activities, products and culture, organization of events
- Museum of Ustica: information on island's history, natural environment and biodiversity (visitors, schools)
- Personal information of stakeholders regarding several issues; information to beach users and visitors
- Brochures and website with modern and friendly interface

Networking and training

- UST participates in a wide MPA network at a national and international level (Italian MPAs, MedPAN, WWF) and Conferences that ideas and experiences are exchanged

ISSUES

1. Inadequate funding, no permanent and experienced staff
2. MPA closely linked to Municipality and hierarchical structure of management body: time consuming bureaucratic processes in order for the MPA to run an activity or take any decision or action; limited and unqualified personnel provided to the MPA
3. Stakeholders- Social aspect: although they identify the advantages perceived by the MPA, there is high expectation towards the MPA to produce more benefits for them
4. Past experience from Coastguard (past authority) has prompted lack of trust from local community that took a major effort from the new Director to earn back, and major financial needs since no restoration and maintenance had taken place before (e.g. 20 out of 35 diving buoys were destroyed and diving boats were anchoring until replacement of buoys)

LESSONS LEARNT

1. Past experience is major issue that should be considered in MPA management, and is closely related to conservation objectives, stakeholder engagement, communication and trust between stakeholders, users and the MPA
2. Small local and isolated communities have strong bonding relationships, hence face-to-face interaction is of extreme importance. Conflicts are generally low, but personal relationships have implications on reporting illegal activities and enforcement
3. The spatial range and geographical nature in terms of isolated islands for instance, the years of efficient management and the past history of each case study make it unique from the aspect of its management, communication and needs

REFERENCES

Sanfilippo M, Pulicanò G, Manganaro A, Reale A, Cortese G, 2009. Tyrrhenian Upper Waters in the Ustica Island (Marine Protected Area, Sicily, Italy). International Journal of Ecology, 7 pp. doi:10.1155/2009/161609

Ustica MPA web portal: www.ampustica.it

KEY INFORMANTS:

MPA Director: **Dr. Giuseppe Di Carlo**

CO.R.I.S. (Cooperativa Ricerche ed Indagini Scientifiche soc. coop.): **P. Baiata**

Individual management evaluation for Ustica MPA

YEAR 2014		
Name of the indicator	**Total score**	**additional score**
Existence of legislation on MPAs	1	1
Existence of a functional management body	6	
Existence of a updated management plan	2	
Financial resources allocated to the MPA	2	
Patrol and regulation enforcement	4	1
Seawater quality	0	0
Focal habitats´ conservation condition	F	1
Focal species abundance and population structure	2	3
Management of fishing effort	0	2
Diving	4	2
Boating and anchoring	2	1
Action on alien invasive species	1	0
Existence of outreach activities	6	1
Management of visitors presence	6	3
Networking and training	2	2
Coordination with stakeholders and planners	4	4
Status of focal physical, cultural and spiritual features	E	
Climate change awareness and actions°	0	1
Alternative Livelihoods and/or Income Generating Activities (AL/IGA)	2	1
Local perception of the MPA	3	2
Action on litter	1	1

CASE STUDY 4

CABO DE PALOS, *MURCIA, SPAIN*

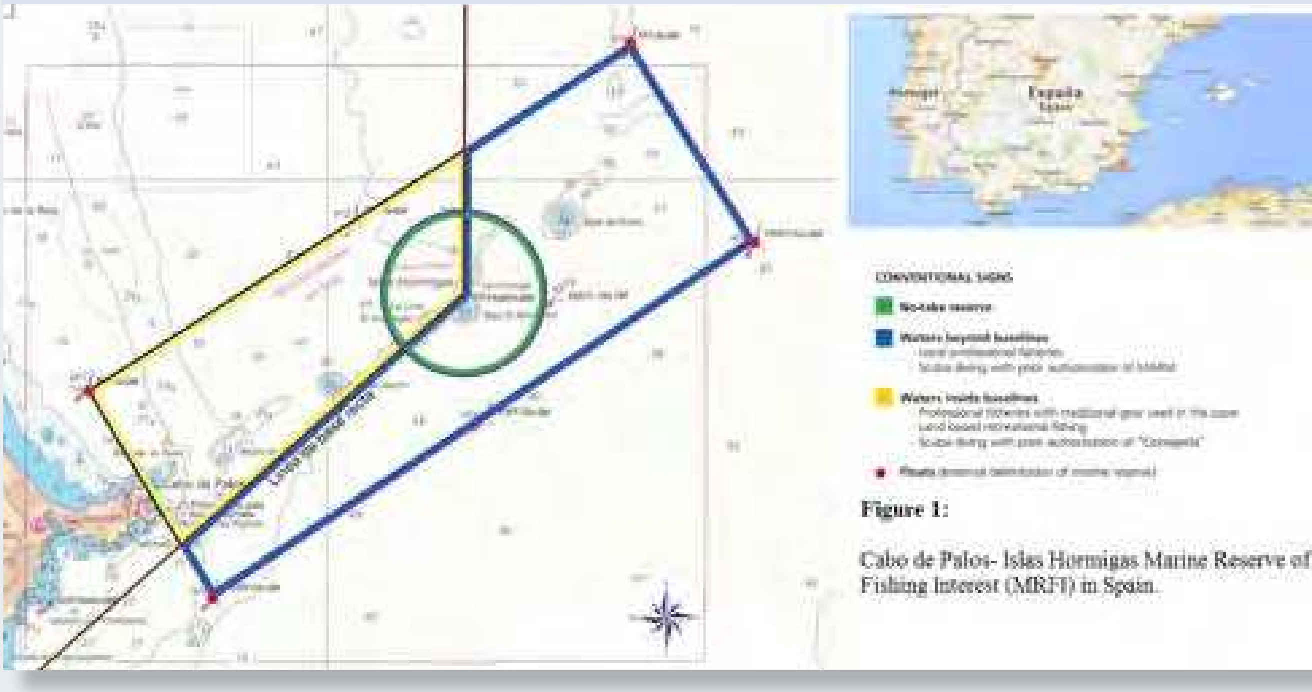


Figure 1:

Cabo de Palos- Islas Hormigas Marine Reserve of Fishing Interest (MRFI) in Spain.

Background

Cabo de Palos – Islas Hormigas (CPIHMR) was declared officially a Marine Reserve of Fishing Interest (MRFI) under the Ministerial Order, June 22, 1995 (Central Government) and decree n'15/95, March 31st, 1995 (Autonomus Community of the Region of Murcia). The establishment of CPIHMR (19431ha) was based on a comprehensive study on marine ecosystems of Murcia Region carried out by the Departamento de Agricultura, Ganadería y Pesca de la Región de Murcia in 1992 (TRAGSATEC, 2007) were Cabo de Palos was selected for its high degree of biodiversity, namely the Posidonia oceanica beds, rocky coral beds and marked marine dynamics (Vandeperre et al., 2006; Garcia-Charton et al., 2007; Esparza Alaminos 2010). Its mission is to protect, regenerate and develop resources of fisheries interest to maintain sustainable fisheries, enabling artisanal fishermen in the area to preserve their traditional way of life.

LEGISLATION AND MANAGEMENT

Adequate legislation on MPAs

- MPAs in Spain have been traditionally established based on the fisheries criteria (Martínez de Pazos, 2012)
- The external waters of the CPIHMR are under the authority of the General Secretariat of Maritime Fisheries (Ministry of Agriculture, Fisheries and Food); the inland area under the Ministry of Agriculture and Water of the Autonomous Community of the Region of Murcia, who are responsible for the fishing and aquaculture activity of the entire region.
- NATURA 2000
- SPAMI area (2001, Mar Menor and Oriental Mediterranean zone of the Region of Murcia coast)
- National ICZM strategy (2007) after the publication of the communication "T*owards sustainable coastal management in Spain*" (2005) by the Ministry for the Environment and Rural and Maritime Affairs that served as a roadmap for sustainable coastal management

Functional management body

- Management body: representatives of Ministry at Murcia and representatives of Regional Ministry at Cartagena, with main responsibilities to administer, maintain and patrol all the fishing and aquaculture activities in the Region of Murcia and not in the particular MPA
- Advisory Committee: representatives of the administration, the University of Murcia, the research institution IEO, the fisheries sector consults with the management board regarding decisions in the Reserve

Updated management plan

- Management plan outlines the objectives and regulation of the MPA
- The last update of the management plan involves the recent regulation on recreational diving
- It is a general objective and doesn't have targets or outline what they will measure in order to know if the objectives are being reached

Financial resources allocated

- Annual funding coming from the Ministry and the Region of Murcia
- Decreasing trend since 2011, which has led to the reduction of activities in the Reserve (e.g. surveillance, maintenance etc.)
- Monitoring is funded separately through the European Maritime and Fisheries Funding (Monitoring Committee)

Patrolling and regulation enforcement

- Responsible authority: coastguard (surveillance of the wider area –Region); semi-private company through an agreement
- The guards have the right to enforce the law and give penalties, or seizure
- Due to the financial crisis, there have been complains by the management board and locals that the surveillance is limited and illegal fishing takes place, although the last year the surveillance frequency has improved
- Semi-private company accomplishes maintenance activities when users report them and the budget allows
- There are suggestions that new technologies should be introduced; fishers and divers would like to participate in the surveillance

Coordination with stakeholders and planners

- Meetings are not frequent (< 1-2 meetings per year with the scientific/monitoring committee) but in the recent years due to the need for mitigation of diving has prompted more frequent engagement meetings with relevant stakeholders and the Monitoring and Scientific Committee
- Decisions are lack bottom-up approaches
- Successful examples of conflict resolution: initial opposition of fishermen when the MPA was established fishermen- currently fishermen support the MRFI; conflict with diving tourism through information and meetings the diving capacity has reached a consensus

FEATURES OF INTEREST

Seawater quality (SWQ)

- Currently there is no monitoring regarding the seawater quality

Monitoring of focal habitats and species populations health status

- Monitoring is achieved by the relevant Committee and external partners
- Status of habitats is considered favourable
- Monitoring of habitats and keystone species - UVC and digital photography techniques: *Posidonia oceanica* is monitored in terms of density and coverage
- key species are monitored for rocky reefs (*M. turnicata*) and coralligenous (coverage, density, abundance and biomass, every two years; gorgonians *Paramuricea clavata*, *Eunicella singularis*), and are characterized in terms of morphometric descriptors and occurrence of necrosis through photographic surveys (gorgonians). Gorgonians have recovered well after the massive mortality of 2007
- Monitoring of fish populations by UVC (56 fish species) – status has decreased in the CPUE of key fish species the last 3 years due to limited surveillance and poaching, but since the improvement of surveillance the last year it is soon expected to increase again

Status of focal physical, cultural and spiritual features

- No monitoring or assessment on the status of focal physical, cultural and spiritual features
- Some diving centers promote these features (e.g. shipwrecks) to the visitors, organise events, publish brochures, books and documentary movies
- In the area there is the National Museum of Underwater Archaeology

Local perception of the MPA

- Local community and users perceive CPIHMR as generally beneficial for the community; positive change of users' attitudes (e.g. fishermen)
- As dive industry is not well controlled there is concern about its viability for the future (Hogg, pers. communication)
- Lack of enforcement and surveillance has created scepticism about the reserve as illegal fishing heavily impacted it (Hogg, pers. communication)

Alternative Livelihoods and/or Income Generating Activities (AL/IGA)

- No specified knowledge on AL/IGA
- People recognise opportunities for the dive industry but not for any other industry, as traditional fishing is diminishing

PRESSURES

Monitoring and management of fishing effort

- Small number of artisanal fishing vessels (currently 7 fishing boats; Garcia-Charton, pers. communication) traditionally operating in the CPIHMR with trammel nets and longlines; authorization is compulsory (Esparza Alaminos O., 2010; Stelzenmüller et al., 2008)
- Decreasing trend- limited number of licenses, which their number cannot be increased by law, nor being sold; licenses can only transmitted between close family members (Garcia-Charton et al., 2008; Vanderperre et al., 2006)
- Monitoring through logbooks (professional fishermen are obliged to deliver every year to the CPIHMR Authority) and its impact (visual census) under standardized protocols
- Monitoring of landings at the regional scale
- Recreational fishing is explicitly prohibited in all the marine reserve. However illegal underwater fishing has been frequently reported which has seriously impacted the fish stocks the last 3 years (e.g. *Epinephelus marginatus, Diplodus sp., Sciaena umbra, Dentex dentex, Sphyraena virensis* etc.).

Monitoring and management of diving activity

- Currently diving is one of the most important socio-economic activities in the area, with about 6000 dives per year take place in the 5 diving spots that exist in the CPIHMR (Garcia-Charton, pers. communication)
- There is a significant increase of diving activity the last years
- Monitoring through logbooks (report) of diving centers to the CPIHMR every year; monitoring of impacts from diving using the indicator species *E. singularis* and *M. truncate*
- Evidence indicate excess of diving capacity, improper diving behaviour and high risk for degradation of habitats and biodiversity loss in the CPIHMR
- As a response, the management authority updated the legal framework and set a diving quota of 250 dives per day in high season, as well as charging each diver a fee (3.45€)

Monitoring and management of boating and anchoring

- Intensive small recreational boats boat and Jet Ski traffic in the wider area (IMP-Med, 2014)
- Recreational boats are permitted to pass through the MPA and moor in the vicinity (creeks and beaches, marine in the port of Cabo de Palos) where special mooring sites exist (diving sites)
- The guards of the marine reserve control for the compliance of mooring limitations
- Anchoring is prohibited inside the Reserve
- There is work in progress to update the law for mooring capacity

Monitoring and management of visitors presence

- There is no standard monitoring of visitors, apart from divers

Action on alien invasive species (AIS)

- Although here is no standard monitoring plan on AIS, some monitoring rom the relevant Committee has been done: monitoring of the "thermophilic" warm-Atlantic species (e.g. *Serranus atricauda, Pseudocaranx dentex, Parapristipoma octolineatum, Sparisoma cretense, Scorpaena maderensis*) within the CPIHMR and neighboring areas; photographic survey to study the evolution of the coverage of *Oculina patagonica;* genetic studies have been undertaken in the area using the species *Diplodus sargusas* as a model (González-Wangüemert et al., 2002; 2004)
- Sightings of invasive species are also reported in the Monitoring Committee mainly by fishermen and divers
- Trend of AIS is increasing in terms of abundance and biomass (Garcia-Charton, pers. communication)
- Sources of invasion have not been officially recognized in the Reserve, but have been assessed based on scientific literature (e.g. Otero et al., 2013b)
- Currently there is no action or information of public regarding AIS

Climate change awareness and actions

- No action for promoting awareness on CC is made
- Actions include monitoring of AIS and mortality events or recovery of coralligenous, although not consistent

Action on litter

- No action on marine litter is taken

COMMUNICATION & OUTREACH

Existence of outreach activities

- Some interpretive tools and facilities: visitor centre, informative signs, leaflets
- Limited information towards public; no education activity
- Some informative meetings from the Monitoring Committee aiming at diving centers (diving behaviour underwater the risks of diving for marine life)

Networking and training

- Involvement of the Reserve in international and national meetings, Conferences and Symposiums.
- Collaborations with international and national research and academic institutes for exchange of experiences, projects and development of common monitoring frameworks

ISSUES

1. Conflicts between traditional fishing (culture) vs. diving (tourism); spatial overlap of activities since the Reserve is quite small and diving sites is narrow (Garcia-Charton, pers. communication)
2. The increase of diving and action towards mitigation of the activity has raised controversial discussions and scepticism as diving is the most important socio-economic activity in the area currently (Garcia-Charton, pers. communication)
3. Eclipse of traditional activities in the area (e.g. traditional fishing)
4. Limited surveillance due to inadequate funds has raised illegal fishing (mainly spear fishing with tanks and lights, particularly during night), which has caused the rapid drop of the fish stocks the last three years (Garcia-Charton, pers. communication). The last year surveillance has improved, however still illegal fishing is reported and stocks are recovering
5. Work load and responsibilities of administration in the wider area (region) and on several issues (fisheries and aquaculture) has resulted in limited human and time resources to comply with the multiple needs of the Reserve
6. Lack of accurate and measurable objectives in management plan can assist conservation actions and compliance of users

LESSONS LEARNT

1. Important to promote responsibilities to lower levels of authorities with specific focus on the MPA
2. Importance of surveillance and develop local responsibility
3. Laws need to be realistic and adjusted to MPA needs, while clear measurable objectives can ensure strong conservation tool for managers in order to make sound decisions and monitor management progress

REFERENCES

Esparza Alaminos O., 2010. Estudio de la pesca artisanal en el entorno de la reserva marine Cabo de Palos- Islas Hormigas. Estrategias de pesca, efecto de la proteccion y propuestas para la gestion. PhD Thesis. Facultad de biologia, Departamento de ecologia e hidrologia, Universita de Murcia

García-Charton J.A., Pérez-Ruzafa A., Marcos C., Claudet J., Badalamenti F., Benedeti Cecchi L., Falcón J.M., Milazzo M., Schembri P.J., Stobart B., Vandeperre F., Brito A., Chemello R., Dimech M., Domenici P., Guala I., Le Diréach L., Maggi E., Planes S., 2008. Effectiveness of European Atlanto-Mediterranean MPAs: Do they accomplish the expected effects on populations, communities and ecosystems? Journal for Nature Conservations 16, 193-221.

González-Wangüemert M., Marcos C., García-Charton J.A., Pérez-Ruzafa A. (2002) Importancia de la genética de poblaciones en la gestión de áreas marinas protegidas. In: Aragonés, E. (Coord.) Simposi mediterrani d'espais marins y costaners protegits. Generalitat de Catalunya – UNEP-RAC/SPA: 339-348.

González-Wangüemert M, Pérez-Ruzafa A, Marcos C, García-Charton JA (2004). Genetic differentiation of Diplogus sargus (Pises: Sparidae) populations in SW Mediterranean. Biol. J. Linn. Soc. 82: 249-261.

Marine Reserves Spain: www.reservasmarinas.net/reservas/cabopalos/legislacion.asp

Martínez de Pazos, S.R., 2012. 25 years of Spanish fisheries marine reserves: lessons learnt. Transversal Workshop on spatial based fishery management. GFCM Headquarters, Rome (Italy). 6-8 February 2012, Dirección General de Recursos Pesqueros y Acuicultura.

Stelzenmüller V., Maynou F., Bernard G., Cadiou G., Camilleri M., Crec'hriou R., Criquet G., Dimech M., Esparza O., Higgins R., Lenfant P., Pérez-Ruzafa Á., 2008. Spatial assessment of fishing effort around European marine reserves: Implications for successful fisheries management. Marine Pollution Bulletin 56, 2018-2026.

TRAGSATEC, 2007. Characterization, diagnosis and definition of proposals for marine ecosystem management included in de area of Tiñoso Cape (Region of Murcia). Synthesis document. Consejeria de Agricultura y Agua, Direccion General de Ganaderia y Pesca, Servicio de Pesca y Acuicultura. 29pp.

Otero, M., Cebrian, E., Francour, P., Galil, B., Savini, D. 2013. Monitoring Marine Invasive Species in Mediterranean Marine Protected Areas (MPAs): A strategy and practical guide for managers. Malaga, Spain: IUCN. 136 pages. ISBN:979-2-8317-1615-2

Project on Integrated Maritime Policy in the Mediterranean (IMP-Med): http://www.imp-med.eu, Cited in 24.03.2014

Vandeperre F., Higgins R., Santos R.S. & Pérez-Ruzafa A. (Coord.) 2006. Fishery Regimes in Atlanto-Mediterranean Europe an Marine Protected Areas. EMPAFISH Project, Booklet nº2. 97 pp

Interviews from key informants:

KEY INFORMANTS:

Dr. Jose Garcia-Charton, Member of Monitoring Committee in Cabo de Palos-Islas Hormigas MPA

K. Hogg, University of Murcia, Department of Economics, Murcia, Spain

Individual management assessment for Cabo de Palos- Isla Hormigas Marine Reserve

YEAR 2015		
Name of the indicator	Total score	additional score
Existence of legislation on MPAs	1	3
Existence of a functional management body	5	
Existence of a updated management plan	5	
Financial resources allocated to the MPA	2	
Patrol and regulation enforcement	6	1
Seawater quality	0	0
Focal habitats´ conservation condition	F	2
Focal species abundance and population structure	3	4
Management of fishing effort	4	3
Diving	4	2
Boating and anchoring	4	2
Action on alien invasive species	1	-1
Existence of outreach activities	2	0
Management of visitors presence	2	0
Networking and training	1	2
Coordination with stakeholders and planners	4	3
Status of focal physical, cultural and spiritual features	E	
Climate change awareness and actions°	4	1
Alternative Livelihoods and/or Income Generating Activities (AL/IGA)	0	0
Local perception of the MPA	2	3
Action on litter	0	0

CASE STUDY 5

PORT CROS MPA, *FRANCE*

Background

Port-Cros National Park (PCNP)1 was created in 1963. It is the oldest MPA in the Mediterranean and the first National Park in France. The National Law for Parks (2006) modified the structure and organization of all National Parks in France and introduced the concept of potential adhesion area (Barcelo and Boudouresque, 2012; Boudouresque et al., 2013). Based on this Law, the Charter was established for PCNP in 2012 which aims to amend its territory including Port-Cros, Porquerolles and Le Levant islands (Port Cros and Porquerolles as hearts of the Reserve), 11 coastal municipalities ('accessible membership area') and an 'adjacent marine area'. The Charter will be finalized in 2015. The majority of land in Porquerolles island (1000ha) is public which were bought from the French government in 1972, while 254ha are still under private ownership. A previous attempt in 1974 for Porquerolles island to be incorporated in the PCNP had failed, but in May 4, 2012 due to the Law of 2006 was finally incorporated into the PCNP.

LEGISLATION AND MANAGEMENT

Adequate legislation on MPAs

- SPAMI area
- Part of the PELAGOS Sanctuary for marine mammals (PCNP coordinates the French party)
- Natura2000 site, responsible for islands and salt marshes in Hyeres
- National Park
- The Regional plan and the Charter oblige PCNP to involve terrestrial and marine actors in decisions

Functional management body

- Complicated structure: The area is divided in sectors for its best management. There is one Director and co- Director; several Committees with different responsibilities (planning and development, communication, informatics and GIS, financial); the General Secretary and managers responsible for different missions; the Board of Administration (state and regional representatives) and the Scientific Committee compiled by established scientists nominated by the Minister of Environment, and the President assemble the management board
- Apart from the responsibility to administer and manage the marine and terrestrial parts of the Park, several management responsibilities and scientific/technical assistance in territories in and outside the Park (e.g. terrestrial parts of CELRL, Porquerolles and Giens; operator of NATURA in Port Cros, Porquerolles, Le Levant islands and salt marshes of Hyeres; National Botanic Conservatory of Mediterranean etc.)
- The personnel is compiled by 100 people (80 permanent, 20 temporary contracts) with responsibilities mainly at the field

Updated management plan

- Management plan updated every 5 years, unless gaps or urgencies noticed
- DOCument of OBjectives ("DOCOB")
- Charter updated every 15 years, includes clear management objectives and indicators that are set in collaboration with stakeholders under specific timeframes

Financial resources allocated

- Annual funding from the Ministry covers 80% of the operational needs and most of the salaries, and is received in 4 parts
- Additional annual funds from foundation regarding specific actions, e.g. fuels, energy etc. (TOTAL: http://total.com/en)
- Additional income which goes to the PCNP and is redistributed to the sectors: by selling Park's products; renting land (agriculture and winery); sustainable activities (bike renting); tourism accommodation; port use (boats)
- Attraction of private companies that aim to increase their publicity and image (e.g. insurance company for the creation of paths for disabled people)

3. *Personal experience was mainly in the Porquerolles Island, which was recently embodied in PCNP. Although great effort has been made to increase management knowledge and response in the marine part, there are still inequalities between the two islands of Port Cros and Porquerolles. Since the personal experience and interviews of the author were mainly in Porquerolles island, information regarding the coordination of the whole Park may be inconsistent in some cases, and does not imply that management response is equally applied in both islands.*

Patrolling and regulation enforcement

- Responsible authorities: Port authority (special agreement between the MPA and Coastguard) and local/national police
- The Park (MPA rangers) has the authority to verbalise penalties when there is a violation and establish new laws within the limits of the MPA. The entitlement of 'police officer' comes from the Ministry of Environment
- No particular violations or illegal activities have been reported

Coordination with stakeholders and planners

- Frequent meetings (about once per month) between and within the administration committees, each sector and agents
- Technical meetings targeted to specific issues (e.g. financial); external meetings with the regional council and stakeholders; meetings of the Scientific Committee (average 75% participation between 2005-2012)
- Regional and national laws oblige the PCNP to involve stakeholders from land and sea. In cases of conflicts the Park organizes consultations between groups trying to reach a common solution.
- During the Charter development, stakeholders and residents were engaged and shared their opinions, needs and targets in order to be integrated within the Charter objectives

FEATURES OF INTEREST

Seawater quality (SWQ)

- SWQ is considered favourable
- Emergence plan (national plan MARPOL) for addressing marine pollution and protecting of the coast in PCNP
- Some pollution in water quality has been noticed in the port of Porquerolles (Mr. Moreau, personal communication)

Monitoring of focal habitats and species populations health status

- Monitoring plans are established after an open call, and is selected based on feasibility, cost, effectiveness; can be updated every year
- Monitoring is performed by external organizations (i.e. research centres, universities etc.) and by trained staff
- Systematic monitoring of fish communities (visual census of 25 fish species) using the FAST method 2 times per year (before and after summer); marine mammals following the CIESM protocol; important/protected/endangered marine habitats and species (*Lithophaga lithophaga*; Cystoseira forests; *Lithophyllum*; *E. marginatus; Caretta caretta*); and seabirds (e.g. *Falco peregrinus; Otus scops; Puffinus yelkouan; Sylvia undata*)
- Systematic monitoring of land: 6 species of bats, endemic fauna and flora (677 taxa, including 34 of important heritage, e.g. *Genista linifolia*); amphibians and reptiles (e.g. *Discoglossus sardus*; *Phyllodactylus europeus*); insects; citizen science database; bank seeds developed by the Botanic Conservatory of Porquerolles for the conservation of endemic Mediterranean plant varieties and species
- Status of habitats is healthy and species diversity is high: *P. oceanica* status varies from pristine to moderate-low; photophilus reef habitats varies from high to very high; coastal detrital habitats vary from high to moderate; coralligenous varies from pristine to good in PCNP (Astruch et al., 2012; Boudouresque et al., 2004).
- Status of fish populations: fish species (e.g. groupers) has shown increasing trends in terms of biomass and number of individuals

Status of focal physical, cultural and spiritual features

- Status better since the creation of the PCNP
- Promotion, discovery of wrecks, Museum of Porquerolles, traditional antiquities related to the island's culture (e.g. windmills) etc.
- Very high costs for maintenance and development of these features for the Park (National Parks France, 2014).

Local perception of the MPA

- Local community has accepted and identifies the goods and services from PCNP
- No specific conflicts between the local community for land uses
- Limited awareness for the value of the marine part
- There is also the perception of a 'traumatic' experience in local community coming from the earlier establishment of PCNP due to the strict regulations that were set. This resulted to the slow abandonment of the island from its residents. Since then, with the realization of the importance of stakeholder engagement and the sharing of common visions with local community there has been a tremendous progress as described above. Currently with the establishment of the Charter, the PCNP has also made a great effort in order to include the opinion and suggestions coming from the local community (Mr. Moreau, personal communication)

Alternative Livelihoods and/or Income Generating Activities (AL/IGA)

- Knowledge of local business and main activities in Porquerolles (tourism and agriculture)
- PCNP promotes economical models through tourism, environmental activities; local products
- Socio economic study that studies the impact of the PCNP to local business, which showed positive effects

PRESSURES

Monitoring and management of fishing effort

- There are 6 traditional small scale fishermen (<12m boat length) in Porquerolles and about 10 coming from Hyeres and Lavandou (Cadiou et al., 2009). Commercial fishing is compatible with conservation objectives (Cadiou et al., 2009)
- Fishermen are obliged to sign the Charter in order to be allowed to fish in the PCNP, and follow the regulations (e.g. gear modification, limited amount of gear per fisher, limiting effort, spatial and temporal closures; Boudouresque et al., 2004), Total catch ranges from 2.6 to 4.1 kg ha-1 year-1 (Cadiou et al, 2009)
- Four monitoring strategies are established for small-scale fisheries: on-board observers, licenses, logbooks (from the Ministry and VMS) and a questionnaire that are obliged to fill in when they deliver their annual logbook (cross validation of data)
- Monitoring of recreational fishing: licenses; logbook where catch reporting is necessary in order to renew license; online application (voluntarily) to record their catches and in return they receive feedback of their catch trends, which has been noticed to have stimulated fishermen interest and improves their understanding on the importance of providing this kind of information.
- For both artisanal and recreational fishing some illegal activity has been recorded close to the borders of the MPA (Porquerolles; Mr. Moreau, personal communication)

Monitoring and management of diving activity

- Monitoring: number of divers per site and level of divers
- Diving centres have to sign a special agreement based on the Charter that ensures the responsible diving activity in the area, and are trained regarding diving behaviour
- Mooring sites with 'jumper buoys' for which there is a limit of carrying capacity
- Underwater signs and surveillance from the MPA agents
- In PCNP 60000 dives per year take place, although estimations including the activity in Porquerolles is much higher (Mr. Moreau, personal communication), which makes mitigation of the activity difficult (Barcelo and Boudouresque, 2012; Gerardin, 2012)

Monitoring and management of boating and anchoring

- There are about 300-350,000 recreational boats per year in PCNP (Barcelo and Boudouresque, 2012; Gerardin, 2012). Mitigation of recreational boats still remains a big challenge in Porquerolles, although relevant regulation exists (Mr. Moreau, personal communication)
- Anchoring in Porquerolles threatens marine species such as *Pinna nobilis* and *P. oceanica* (Mr. Moreau, personal communication); implementation of mooring buoys is in progress, which is expected to eliminate issues of overcapacity and anchoring in the island (Hunkeler, 2012)

Action on alien invasive species (AIS)

- Has been reported as an important issue in the area
- Action to limit invasion, such as the *Caulerpa cylindracea* in all hard substrate habitats over the depth of 50m, and *Womersleyella setacea* targeting sublittoral reef with photophilous macroalgae and the coralligenous threatening by change of composition and structure of these communities (Ruitton et al., 2009; Cottalorda et al., 2011)
- *Caulerpa taxifolia* has been successfully encountered mainly by eradication, action taken about 1-2 times per year

Management of visitors presence

- In Porquerolles the number of visitors is estimated about 1 million per year and can reach up to 12000 visitors per day during summer. The total number of visitors in the whole Park is estimated about 2 million visitors influx per year (National Parks France, 2014)
- Collaboration with companies of navigation, in order to monitor and mitigate tourism flows (Hunkeler, 2012).
- Regular surveys of visitors and observations about changes in visitors' behaviour
- Studies on carrying capacity of visitors (naturalistic, biological and social point of view)
- Considerable impact on soil erosion (walking and bicycles)

Climate change awareness and actions

- Monitoring of new species (invasive and sensitive to climate change), temperature and pH
- Continuous education, information (public, users, stakeholders)
- Organization of workshops, conferences and training of volunteers to determine the causes and effectiveness of action regarding climate change and invasion (underway)

Action on litter

- Collection of waste on beaches
- Educational campaigns in schools, organization of events and placement of bins all around the islands

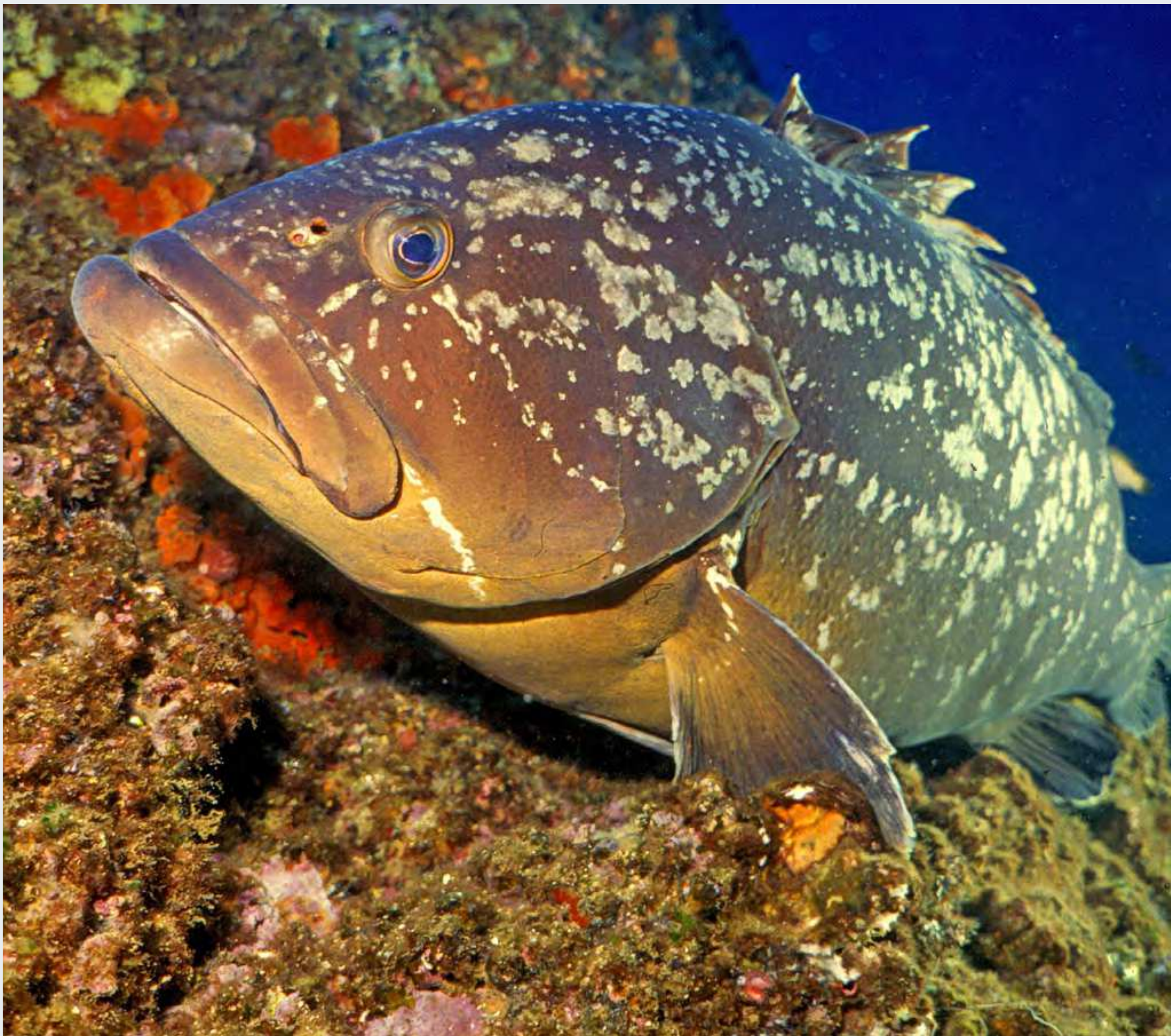
COMMUNICATION & OUTREACH

Existence of outreach activities

- Communication and awareness: reports, brochures, information centres, consultations meetings and workshops with relevant actors, public events for promotion of local goods and tradition, volunteerism and educational activities with local community, information of farmers for biological agriculture and the non-use of chemical substances (pesticides etc.), crowdsourcing web portals, bank of seeds from local varieties of terrestrial fauna, information and training of key actors (diving centres, maritime transportation etc.) on the islands and the mainland (certification of official informative)
- Scientific journal to disseminate new information, approaches and results

Networking and training

- Participation in Mediterranean and national networks of MPAs
- Provides training to the staff of other MPA
- Rangers are trained for one year before returning to service a national park in France in a special school (IFORE)
- In total about 100 scientists have been engaged in the scientific committee voluntarily



ISSUES

1. Although PCNP receives a high amount of funding, considering the huge area and its needs, decreasing funding does not allow implementation of sustainable technology (e.g. boiler, solar panels)
2. Great challenge in terms of effort, staff and investment to establish monitoring and mitigate activities regarding the marine part in Porquerolles
3. Difficult to enforce and patrol the wider area of the PCNP
4. No fee established for users, neither is included in the Charter
5. The implementation of the CHARTE in the future is expected to raise conflicts and opposition particularly for divers and fishermen

LESSONS LEARNT

1. Holistic legislation with clear measures can promote the objectives of the MPAs and support decision-making, with serious positive effect on local community and stakeholders
2. Investment on stakeholder training can benefit MPAs in terms of effort, human resources, dissemination power and cost
3. Importance of strong polyphonic voice of experts of different expertise and frequent meetings can support holistic and sound scientific information of the MPA management (Boudouresque et al., 2013)
4. Organization and hierarchy in responsibilities within the Management consortium has facilitated the communication and decision making for different issues between and within different levels (e.g. administration, scientists etc.)
5. Importance for managers to have the possibility of law enforcement within the MPA borders
6. Stakeholder engagement and bottom up approaches are time consuming processes but are necessary to support conservation objectives and compliance
7. Particular training of MPA rangers specified on needs and background knowledge
8. Important annual funding to be received before the monitoring, and in parts in order to secure transparency and effectiveness
9. Permanent personnel can secure coordinated action and management response for long-term sustainability
10. Training of rangers in special school particularly targeted to MPA needs

REFERENCES

Astruch, P., Boudouresque, C.F., Bonhomme, D., Goujard, A., Antonioli, P.A. et al., 2012. Mapping and state of conservation of benthic marine habitats and assemblages of Port-Cros national Park (Provence, France, northwestern Mediterranean Sea). Sci. Rep. Port-Cros natl. Park, 26, 45-90.

Barcelo, A., Boudouresque, C.F., 2012. Rôle de la recherche dans un parc national: 50 ans de recherche dans le parc national de Port-Cros. Bulletin de la Société zoologique de France 137, 11–24.

Boudouresque, C.F., Cadiou, G., Guerin, B., Le Direach, L., Robert, P., 2004. Is there a negative interaction between biodiversity conservation and artisanal fishing in a Marine Protected Area, the Port-Cros National Park (France, Mediterranean Sea)? Scientific Reports of Port Cros National Park, 20: 147-160

Boudouresque, C.F., Barcelo, A., Harmelin, J.-G., Martin, G.J., Maurer, C., Médail, F., Sellier, G., Viviani, R.-A., 2013. The Scientific Council of a national park, the Port-Cros National Park: 50 years of conservation culture. Scientific Reports of Port Cros National Park 27, 297–317.

Cadiou, G., Boudouresque, C. F., Bonhomme, P., and Le Direach, L. 2009. The management of artisanal fishing within the Marine Protected Area of the Port-Cros National Park (northwest Mediterranean Sea): a success story? – ICES Journal of Marine Science, 66: 41–49.

Cottalorda, J.M., Barcelo, A., Barral, M., Bergere, H., Fromentin, J.Y., Pironneau, E., Houard, T., 2011. Résultats de la campagne d'octobre 2010 de recherche et d'éradication de la Chlorobionte envahissante Caulerpa taxifolia (Vahl) C. Agardh. Scientific Reports of Port Cros National Park 25, 199–202.

Gerardin, N., 2012. Parc National de Port-Cros. 1963-2013. 50 ams d;innovations, La Lettre d'information de l'Institut Oceanograogique Paul Ricard, 11:20-23.

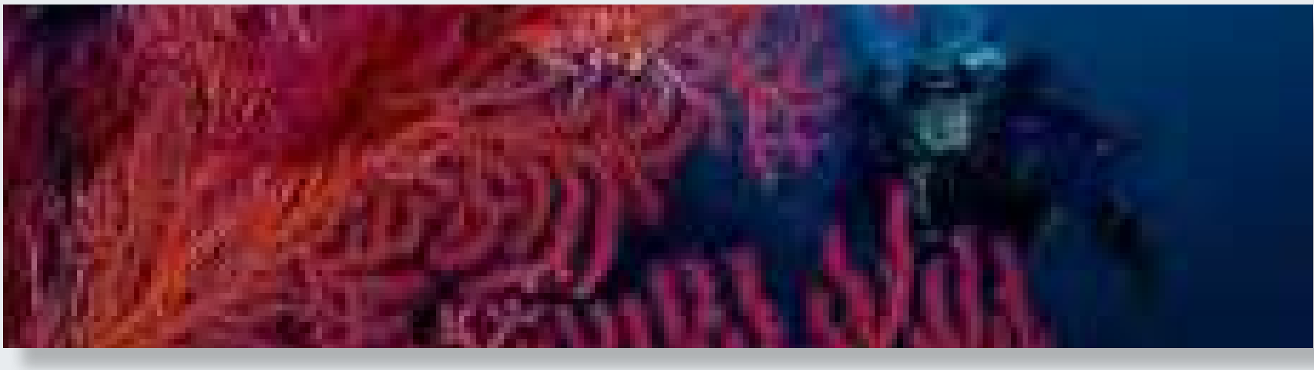
Harmelin, J.G., Ruitton, S., GEM, 2010. Statut du mérou brun (Epinephelus marginatus) dans le Parc national de Port-Cros (France, Méditerranée): état 2008 et évolution en 15 ans. Scientific Reports of Port Cros National Park 147–159.

Hunkeler, M.P., 2012. Pac National de Port Cros. Convention on the Conervation of European Wildlife and natural habitats, Group of Specialists on the European Diploma of Protected Areas, Directorate of Democratic Governance, Culture and Diversity, T-PVS/DE(2012)15. 52pp.

National Parks of France: http://eng.parcsnationaux.fr/layout/set/fiche/content/view/full/7567

Ruitton, S., Thibaut, T., Cottalorda, J.M., Verlaque M., Bonhomme, P., Lassauque, J., Fourt, M., 2009.

Evaluation de l'impact de Caulerpa racemosa sur les communautés benthiques coralligènes du Parc national de Port-Cros: les peuplements patrimoniaux de Cystoseira spp. et de Corallinaceae. GIS Posidonie publ., Marseille: 1-57.



KEY INFORMANTS:

Sector's chief of Porquerolles: **Serge Moreau**
Assistant of the sector's chief of Porquerolles: **Laurent Maxime PCNP officer, Park's rangers and staff**

Individual management assessment for Port Cros National Park

YEAR 2014		
Name of the indicator	**Total score**	**additional score**
Existence of legislation on MPAs	1	3
Existence of a functional management body	6	
Existence of a updated management plan	5	
Financial resources allocated to the MPA	2	
Patrol and regulation enforcement	7	2
Seawater quality	1	3
Focal habitats´ conservation condition	F	2
Focal species abundance and population structure	4	4
Management of fishing effort	4	3
Diving	3	3
Boating and anchoring	3	2
Action on alien invasive species	2	2
Existence of outreach activities	8	1
Management of visitors presence	6	3
Networking and training	3	3
Coordination with stakeholders and planners	4	4
Status of focal physical, cultural and spiritual features	B	
Climate change awareness and actions°	8	1
Alternative Livelihoods and/or Income Generating Activities (AL/IGA)	2	4
Local perception of the MPA	3	3
Action on litter	2	2

Appendix A, Chapter II

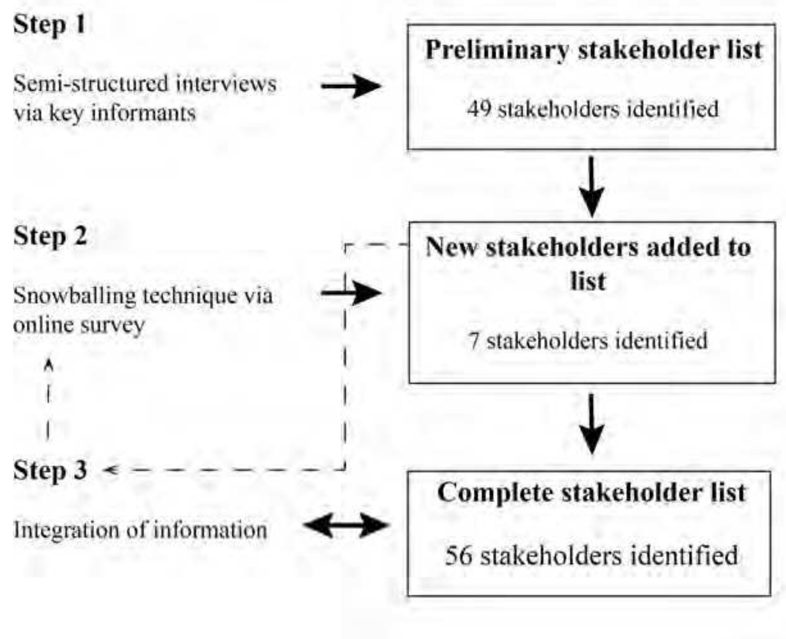


Fig.1. Step by step approach for compiling the full stakeholder list in Portofino MPA. Dashed lines indicate the loop-process for reaching the complete list.

Table 1.

List of stakeholders in the Portofino MPA social network.

Stakeholder category	Abbreviation	Stakeholder name
Academy/ Research	CNR	Consiglio Nazionale delle Ricerche
	CONISMA	Consorzio Nationale Interuniversitario per le Scienze del Mare
	GAIA	Studio Associato Gaia snc
	IMC	Centro Marino Internazionale onlus
	UBICA	UBICA s.r.l
	UNIBO	Universitá di Bologna
	UNIGE	Universitá degli Studi di Genova
	UNIVNIZ	Universitá di Nizza
	UNIVPM	Universita Politecnica delle Marche
Administration	ARPAL	Agenzia Regionale per la Protezione Ambientale Liguria
	COMCAM	Comune di Camogli
	COMPTF	Comune di Portofino
	COMSML	Comune di Santa Margherita Ligure
	GUARCOST	Guardia Costiera
	MINAMB	Ministero dell'Ambiente
	PARCREG	Parco Regionale Promontorio di Portofino
	PROVGE	Provincia di Genova

	REGLIG	Regione Liguria
Diving	APNEA	ApneaCenter
	ASSODIV	AssoDiving associazione
	CDSML	Consorzio Diving S. Margherita Ligure
	COST	Comitato Operatori Subacquei Turistici
Environmental association and NGO	DAPHNE	Cooperativa DAPHNE
	FAI	Fondo per l'Ambiente Italiano
	LEGAMB	Legambiente
	MAREV	Marevivo associazione
	REEFCHECK	ReefCheck Italia onlus
	SLOWFOOD	Slow Food
	STL	System Turistico Locale Terre di Portofino
	WWF	World Wide Fund for nature
Professional fishing	ANAPI	Associazione Nazionale Piccoli Imprenditori della pesca
	CCIAA	Camera di Commercio, Industria, Artigianato e Agricoltura
	COLDIR	Coldiretti
	COOPESCAM	Cooperativa Pescatori Camogli Srl
	FEDERCOOP	Federcoopesca
	LEGAPES	Legapesca
Recreational activities/ Education	CAMONACO	CaMonaco associazione
	LEGANAV	Lega Navale
	LIGVMARE	Liguria Via Mare
	OUTDOOR	Outdoor Portofino
	ZIGUELE	Ziguele associazione
	AQUAGE	Aquarium di Genova
	AQUAVERD	Verde Aqua
Recreational boating	ASSONAUT	Assonautica Genova
Recreational fishing	ALPERI	Alleanza Pesca Ricreativa
	CIRPESSM	Circolo Pescatori Dilettanti Sammargheritesi
	FIPSAS	Federazione Italiana Pesca Sportiva ed Attività Subacquee
	PESTURDRAG	Pescaturismo e Ittiturismo Castel Dragone
Tourism	AGPROMTUR	Agenzia regionale Promozione Turistica in Liguria
	ASALSMLPTF	Associazione Albergatori S. Margherita Ligure e Portofino
	ASBALTIG	Assobalneari Tigullio
	ASCOM	Associazione del confcommercio del turismo e dei servizi della Provincia di Genova
	ASSALTIG	Associazione Albergatori Tigullio
	CONFER	Confesercenti
Tourism transportation	BAGOPAR	Battelli Golfo Paradiso snc.
	TRMATIG	Trasporti Marittimi Tigullio

Table 2.

Questions and response options included in the online survey.

Questions	Response options		Score
Please characterize the strength of tie that you hold with the following actors (a list of stakeholders is shown)	Strong tie		2
	Weak tie		1
	No tie		0
What is your current level of participation in issues relating to the Portofino MPA?	I am not informed about decisions made		1
	I am informed once decisions have been made		2
	Generally I participate but my suggestions are not always taken into account		3
	I collaborate and put forward suggestions that are taken into account when the decision is made		4
	I am actively involved in and responsible for decisions made		5
Which phrase best describes the level of participation that you would like to have regarding decision-making in the Portofino MPA?	I wish not to be informed on decisions related to Portofino MPA management		1
	I wish to be informed once decisions have been made		2
	I am satisfied to simply consult without my suggestions to being taken into account		3
	I wish to actively participate in discussions and provide useful information for decision-making		4
	I would like to be actively involved and responsible for decisions made		5
Which methods do you use for interacting with other local actors related to the MPA?	Online bulletins	Telephone	
	Virtual Encounters	Meetings, Round tables, working groups	
	Social networks	Interviews	
	Exchange of e-mail	Public events, conferences	
	Questionnaires		

Guidelines for increasing information flow and stakeholder engagement in Marine Protected Areas

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Why stakeholder engagement?

Stakeholder engagement promotes transparency and cooperation in decision-making, enhances mutual understanding and assists in the mitigation of conflicts and exploration of possible solutions on the use of marine resources (Pomeroy and Douvere, 2008). However, participation is a complicated and difficult process involving expensive and time-consuming procedures, that often results in a limited audience and restricted engagement potential (Reed et al., 2008). The heterogeneity of groups and the emergence of personal interests may pose conflicts or power inequalities capable of influencing perceptions and decreasing the efficiency of policy interventions (Prell et al., 2009). Managers need to involve diverse groups that represent all users' perspectives and interests in a participatory approach that is in line with existing local plans affecting the area at a broader scale (Tempesta and Otero, 2013). However, successful selection of actors in the engagement process is not straightforward.

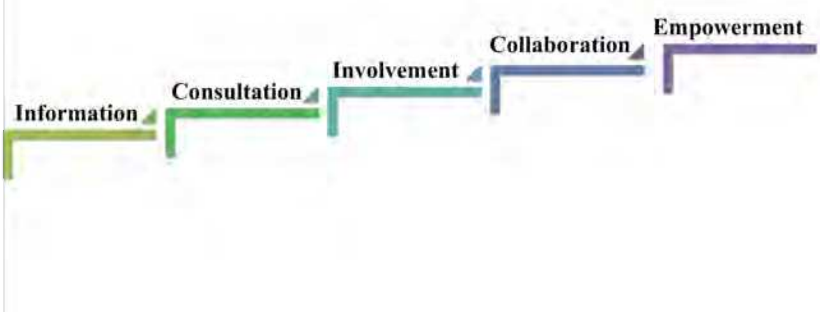

Fig. 1 The participation ladder for stakeholder engagement ranging from simple information provision to more interactive participation strategies that empower stakeholders in resource management decisions (amended from Pomeroy and Douvere, 2008)

It is important to integrate stakeholder engagement because it...

• Creates opportunities to adapt to changing conditions and explicitly incorporates changing values and priorities
• Facilitates social learning, mutual understanding and joint action for sharing a common vision and achieving conservation targets
• Increases transparency in decisions, promotes trust, assists in compliance with agreed solutions
• Monitoring of stakeholder engagement itself may provide feedback for improvement of the process

1. How to monitor stakeholder engagement

Social networks in Marine Protected Areas develop through interactions between people and organizations that are linked to natural resources (Crona et al., 2011). A social network consists of actors (or nodes) holding relationships (ties) with each other. Relationships may differ in their interpersonal strength depending on the frequency and quality of communication between actors (Valente, 2012). Strong ties are characterized by trust-bonded relationships of frequent interaction, while weak ties are less frequent but hold more diverse opinions and are considered valuable for accessing or disseminating new ideas across a network (Granovetter, 1973).

Stakeholder Analysis (SA) helps to identify, characterize and prioritize stakeholders, and may indicate conflicting actors that may hamper the engagement process (Reed et al., 2008). Typically in SA a list of all actors linked to the MPA's management is composed ('roster'). Each actor can nominate missing actors in the list ('snowballing sampling') and characterize his relations to all others included in the roster (Fig. 2). The survey will be finalized when no new names appear in the list. In this point the stakeholder list is completed.

Descriptive information (attributes) may also be collected to provide further exploration of stakeholders and their social network. Although this information may be collected through face-to-face interviews, the use of online surveys is a much cheaper and effective approach to reach a wide range of actors in a short time and low effort (Borgatti et al., 2013).

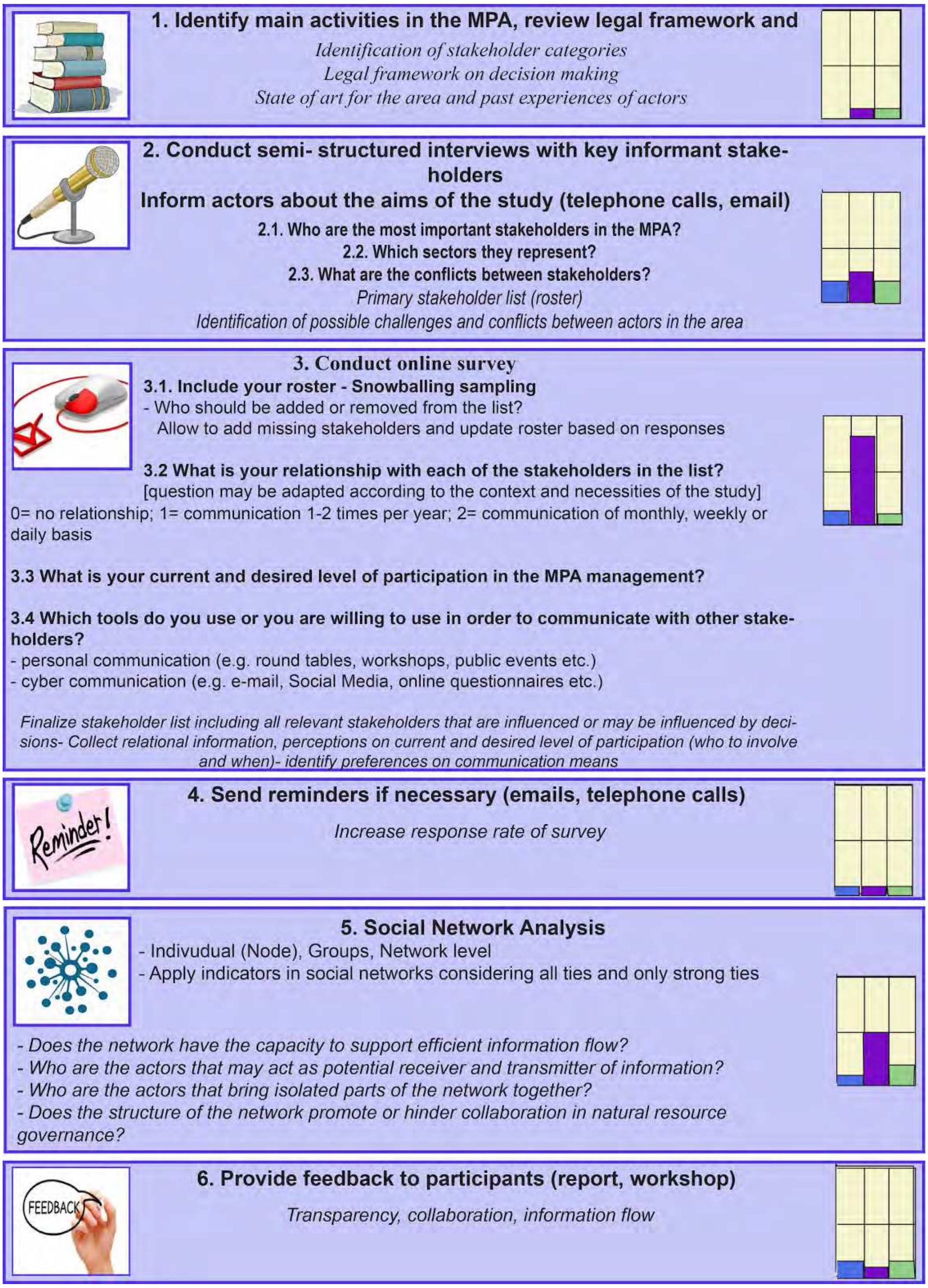

Fig. 2. Step by step approach for applying SA and SNA. The boxes on the right side indicate cost in terms of financial values (blue); time (purple); human resources (green)

A pre-notification of stakeholders via email or telephone that states clearly the scope, consequences and ethics of the study is fundamental. Moreover, reminders may be necessary to be sent during the online survey in order to secure the response of all stakeholders. Finally, it is essential to provide feedback to all participants in the form of a short report at the end of the study.

Social Network Analysis (SNA) complements SA and moves one step further by elucidating relationships among actors developed within a social network. The analysis provides a deep understanding of how the position of actors and the structure of the network may promote or hinder collaboration in natural resource governance (Bodin and Crona, 2009). By applying different measures at the level of nodes, subgroups and network may be applied (Table 1), it allows the identification of central actors with strategic position for receiving or disseminating information (or access to resources) that flows within the network in a short time, due to their multiple contacts (Borgatti and Everett, 2006; Wasserman and Faust, 1994).

Table 1. Suggested indicators that may facilitate the identification of important actors with the capacity to promote information flow and access to resources in natural resource management

Indicator	Level of response	Definition	Outcome	References
InDegree centrality	Individual actors (nodes)	The number of ties received by an actor	-Identify actors with capacity to act as potential receiver of information -Reveals prominent and trusted leaders	Wasserman & Faust, 1994
OutDegree centrality		The number of ties given by an actor	-Identify actors with capacity to act as potential transmitter of information	Wasserman & Faust, 1994
Betweenness centrality		The times that an actor rests between two others that are not themselves directly connected to others or are completely disconnected	-Identify actors that bridge isolated fragments of network ("brokers") -Reveals actors that expand the network	Freeman, 1978
Closenness centrality		The inverse of farness, which is in turn the sum of the distances to all other actors	-Identify actors with capacity to receive information rapidly	Freeman, 1978
Density	Subgroups and network	The proportion of all possible links present in a network	-Shared understanding of the system -Capacity of network to support information flow between stakeholders	Wasserman & Faust, 1994
Centralization		The extent a network is dominated by single actors		
Coreness	Network structure	The strength of actor membership in the core group by measuring the	-Understand the way information flows in the network	Borgatti & Everett, 1999; Semitiel-García & Noguera-

		degree of how close the position of each actor is to the core, using the correlation measure of fit of the core-periphery model	-Identify highly connected actors that keep the network cohesive -Reveals actors with capacity to acts as super-spreaders of information	Méndez, 2012

2. Enhancing information flow and participation in Portofino MPA (Ligurian Sea, Italy)

We have applied SA and SNA in the Portofino MPA to identify central stakeholders with the capacity to act as communication hubs in the identified social network, and explored the presence of core-periphery network structure that may boost information flow and increase participation (Markantonatou et al., 2015). Conducted at a time when Portofino MPA considers initiating negotiating plans to expand the reserve that is expected to stimulate oppositions, this case study is of particular interest and relevance as it adds value and recommendations that can support participation and information flow between stakeholders.

After the conduction of semi-structured interviews and the compilation of a preliminary stakeholder list, an online survey was administered in April 2013. Two rounds of telephone calls and three e-mail notifications were sent to participants to increase the response rate, which reached 82.1% at the end of the survey. The complete stakeholder list included 56 actors related to Portofino MPA management, in which 49 actors were identified initially from the interviews and 7 from the snowballing sampling.

Results showed that the Portofino MPA's social network has an adequate capacity to efficiently support information and knowledge flow between stakeholders. When considering only strong ties the social network is characterized by poor representation of stakeholder categories and limited trust between stakeholders, suggesting possible risks for the collaboration among subgroups and joined action in natural resource management (Fig. 3). On the contrary the network of all ties is more cohesive and seems to operate as a unity with dense communication channels that allow information to reach all actors (Carlsson and Berkes, 2005). This highlights the role of weak ties in promoting deliberation and assuring a higher network capacity for long-term planning (Bodin and crona, 2009).

A core-periphery structure characterizes the Portofino MPA's social network (Fig. 3). The core, compiled by academy[1], administration[2], professional fishing[3], diving[4] and education[5], represents the most central stakeholders that pull together the system acting as central communication hubs in Portofino MPA's social network. These core actors combine central characteristics of trusted leaders and brokers with a great potential to promote the initiative of Portofino MPA enlargement. However, tourism and recreational sectors are predominant user categories that are currently less involved and therefore are located closer to the margins of the network (middling or low coreness values). These facts have important implications for the access to information and resources. Moreover, the fact that the core relies on a few strongly linked actors makes the system vulnerable if these actors dysfunction or were to become inactive (Bodin and Crona, 2009). Outcomes show that all stakeholders desire to participate more actively and take responsibilities in the MPA management, while most of them are familiar with online communication tools. Existing relationships should be strengthen in order to improve participation and boost information flow in Portofino MPA's social network. This provides an important opportunity for the managers of Portofino MPA to create key conditions by combining personal and web technologies for achieving successful stakeholder engagement and sound conservation planning (Markantonatou et al., 2013). The fact that Portofino represents a typical case of an MPA where decisions usually stimulate opposition from users makes this methodology and results applicable to MPAs of similar context.

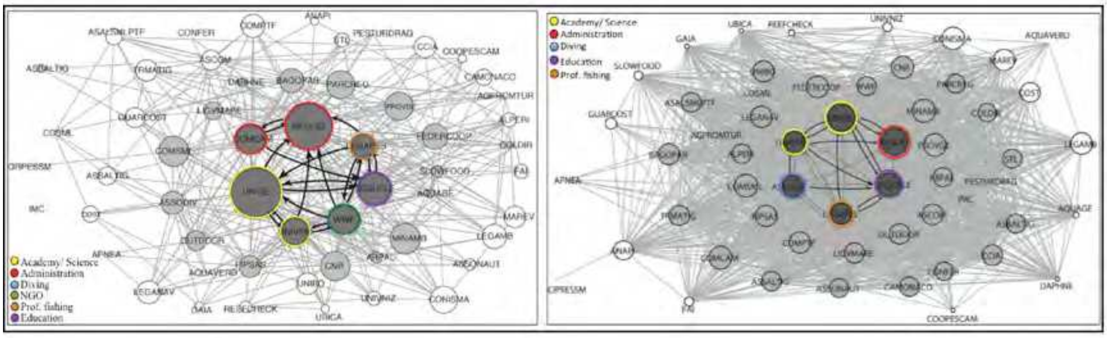

Fig. 3: Social network of Portofino MPA accounting (a) only strong ties and (b) all ties. Size of nodes represents indegree centrality; the colour of nodes indicates the core (dark grey), semi-periphery (light grey) and periphery (white). Bold arrows indicate the strong ties within the core. From Markantonatou et al. (2015).

Management suggestions

- <u>Support</u> the core actors to promote the conservation initiative, to collect information and lead change by using their power, prominence and widespread contacts
- <u>Integrate</u> peripheral actors in MPA management in order to support information to flow more readily and to add adaptiveness into the network
- <u>Strengthen</u> weak ties in order to support the central hubs to widespread information and balance power disparities of core members to control information or circulate exclusively between them
- <u>Create</u> technological environments that integrate e-mail notifications, social media characteristics and dynamic mapping services, that combined with more traditional communication approaches aid to increase stakeholder interaction for the future decision-making process

Stakeholder engagement workshop conducted in Portofino MPA

3. Conclusions

Many conservation initiatives have failed because they pay inadequate attention to the preferences, interests and characteristics of stakeholders (Prell et al., 2009). The capacity of network perspective in exploring the social conditions and their implications in marine resource management has been very recently recognized. SA and SNA are complementary methodologies that provide information and guidance for fostering communication, trust and collective learning in natural resource management by minimizing the effort and risks of management success (Bodin and Crona, 2009).

The suggested guidelines imply a simple and low cost methodology for conservation managers and planners to explore alternative forms of dynamic stakeholder participation and collaborative management. The method incorporates typical engagement barriers, such as restrictions of time, budgetary constraints and availability of stakeholders to participate with their physical presence. However, cost may vary greatly depending on the geographical distance between stakeholders, the selection of communication strategies and tools, and stakeholders' willingness to participate. It may secure representativeness and explicitly include powerful but also remote and marginalized actors in the MPA management for sound governance performance and co-management of resources.

4. References

Borgatti, S.P., Everett, M.G., Johnson, J.C., 2013. Analyzing social networks. SAGE Publications, first ed. London.

Borgatti, S.P., Everett, M.G., 2006. A graph-theoretic perspective on centrality. Social Networks 28, 466–484.

Bodin, Ö., Crona, B.I., 2009. The role of social networks in natural resource governance: what relational patterns make a difference? Global Environmental Change 19, 366–374.

Crona, B., Ernstson, H., Prell, C., Reed, M. and Hubacek, K., 2011. Combining social network approaches with social theories to improve understanding of resource governance, in: Ö. Bodin and C. Prell (Eds) Social networks and natural resource management: uncovering the social fabric in environmental governance. Cambridge University Press, Cambridge, pp. 44-71.

Freeman, L.C., 1978. Centrality in social networks conceptual clarification. Social Networks 1, 215–239.

Granovetter, M., 1973. The strength of weak ties. American Journal of Sociology 78, 1360–1380.

Markantonatou, V., Meidinger, M., Sano, M., Oikonomou, E., di Carlo, G., Palma, M., Ponti, M., Cerrano, C., 2013. Stakeholder participation and the use of web technology for MPA management. Advances in Oceanography and Limnology 4, 260–276.

Markantonatou, V., Noguera-Méndez, P., Semitiel-García, M., Hogg, K., Sano, M., 2015. Social networks and information flow: building the ground for collaborative marine conservation planning in Portofino Marine Protected Area (MPA). Journal of Ocean and Coastal Management. *In press*.

Pomeroy, R., Douvere, F., 2008. The engagement of stakeholders in the marine spatial planning process. Marine Policy 32, 816–822.

Prell, C., Hubacek, K., Reed, M.S., 2009. Stakeholder analysis and social network analysis in natural resource management. Society and Natural Resources 22, 501–518.

Reed, M.S., 2008. Stakeholder participation for environmental management: a literature review. Biological Conservation 141, 2417–2431.

Semitiel-García, M., Noguera-Méndez, P., 2012. The structure of inter-industry systems and the diffusion of innovations: the case of Spain. Technological Forecasting and Social Change 79, 1548–1567.
Tempesta M., Otero M. 2013. Guide for quick evaluation of management in Mediterranean MPAs. WWF Italy, IUCN. 68 pp.
Valente, T.W., 2012. Network interventions. Science 337, 49–53.
Wasserman, S., Faust, K., 1994. Social network analysis: methods and applications, second ed. Cambridge University Press, New York and Cambridge.

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Guidelines for monitoring pressure and impacts from small scale and recreational fishing activity in Mediterranean Marine Protected Areas

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Why monitor fishing activity in Marine Protected Areas

Monitoring and management of small scale and recreational fisheries is one of the most important challenges that MPAs have to encounter from a socio-economical, cultural and ecological point of view. Fishing activity is considered a significant threat due to the exploitation of fish stocks and drifted ghost gears. Intensive fishing may alter the habitats' health status directly through mechanical destruction and abrasion, or indirectly from the resuspension of sediments and lost fishing gear (Bo et al., 2014; Gilman, 2015). Spatial and temporal allocation of fishing effort is fundamental for understanding the impacts from the activity on vulnerable habitats and seafloor integrity (Markantonatou et al., 2014). The present monitoring guidelines mainly focus on the fishing effort perspective and the capacity that this information may provide to address sound management decisions. Prato et al. (2015) provide complementary information on management response regarding the fishing catch.

It is important to monitor fishing activity because…

- Secures long-term, sustainable fisheries from an ecological and socio-economic point of view
- Assists managers and policy makers to mitigate impacts on vulnerable habitats, sustain fish stocks and protect ecosystem goods, functions and services
- Assures sustainable exploitation and equal distribution of marine resources in a transparent and efficient way

1. Guidelines for monitoring small-scale and recreational fishing activity in MPAs: an integration of approaches

· Preparation of monitoring framework: Define the boundaries of study area and create a grid of equally distributed cells (for no point data) as spatial units of reference. In order to monitor fishing activity, geo-referenced layers of bathymetry and habitat distribution should be available. There are several different methods to monitor fishing activity (Fig. 1). The selection of the approach highly depends on the MPA capacity (e.g. staff, budget, trust-bond relationships with fishers and relevant port authorities etc.). The adoption of more than one monitoring strategy, for instance logbooks (systematic monitoring) and interviews and/or questionnaires (once per year, or more frequently), is suggested in order to ensure efficient monitoring data in terms of quantity and quality.

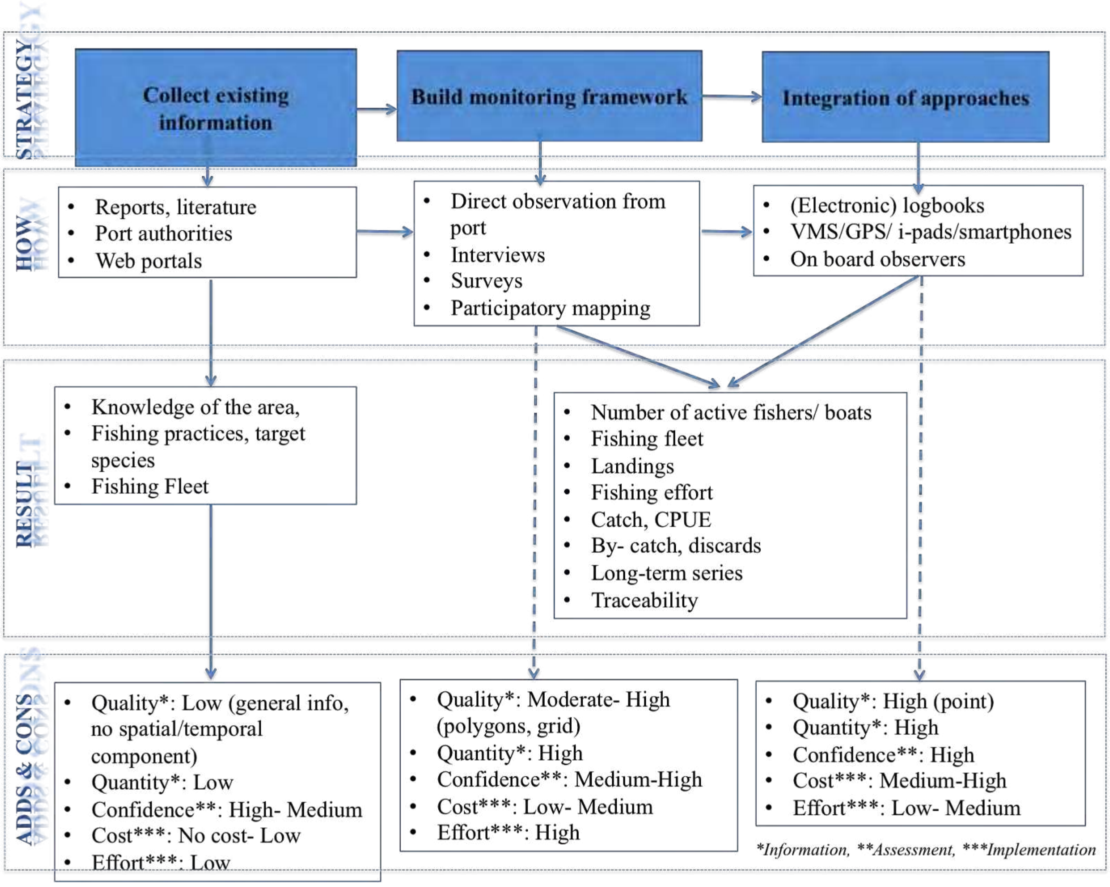


Fig. 1. Monitoring frameworks, sources of information, advantages and disadvantages of each monitoring strategy

· Monitoring of fishing activity: Fishing activity may be allocated based on integration of heterogeneous data if spatial scale is carefully selected. We present a cost-efficient and flexible monitoring protocol (Table 1) that may ensure successful spatial allocation of fishing activity. Trained MPA staff and students, expertised researchers and relevant port authorities may collect field information through the establishment of agreements or collaborations in research projects.

Data can also be collected through advanced web tools (e.g. SeaSketch[1], OceanMapTool[2]), mobile apps (e.g. DONIA[3]) or administered real-time GPS location data transmitted through satellites (AIS, VMS) such as Marine Traffic[4], although the cost increases tremendously considering the provision of smartphones or tablets and Internet access (Markantonatou et al., 2013). Moreover, the average age of fishermen in several Mediterranean countries obstacles the use of high technology unless proper training is offered. In any case new technologies for fisheries data collection advance in providing accurate spatial data and locating violations (e.g. Global fishing Watch)[5].

Table 1. Suggested monitoring framework for fishing effort

Artisanal fishing	Access to information	Outcome
Fisherman & boat name **Port registered** **License number** **Distance from coast (license)** **Boat characteristics (length, LFT, GRT, engine power, engine type)**	EU Fleet Database (http://ec.europa.eu/fisheries/fleet) Coastguard Port authorities	Authorized maximum distance from coast; mapping information when spatial information is absent Fleet description Introduction of non-synthetic compounds (gasoline, oil etc.)
Number of personnel **Salary of personnel** **Nationality of personnel** **Total expenses per year (license, fuel, personnel, gears etc.)**	Interviews Coastguard Port authorities	Labour market Socio-economic, cost-benefit analysis
Fishing ground (area, depth, distance from coast, substrate type, habitat type)	Indicate on map all fishing grounds Use GPS (coordinates of position of net - start and end point of net deployment)[#]	Fishing grounds Mapping accuracy
Fishing gear(s)*/techniques**	Indicate gears in every fishing ground Show a list of fishing practices**	
Gear features	Net height and length, material*	Mapping accuracy

	Line length, number and size of hooks, bait (lines) Number of traps, type, surface, bait	Wear resistance Force of gear practice & retrieval Invasive species (bait)
Months per year	Indicate in every fishing ground per gear, or provide % from total in every area	Fishing effort (per month, per season, per year) Fishing effort (days, trips, hours)
Days per month		
Fishing trips per day		
Number of gears/ hauls per trip		
Hours of gear active **Date & time of gear deployment & retrieval#**		
<u>Additional questions</u> **-Dimension of mesh size, hooks, traps etc.** **-Main catch (target species, number individuals, aver. kg/month)** **- Bait used** **-By catch, discards (species, number individuals, aver. size)** **-Trace of catch (restaurants, local market, direct selling, personal consumption)** **- Cost (fuels, gears, licenses etc.)**	Indicate per fishing ground Collect information on prices from fishermen and restaurants, market	Catch (Aver. kg/year, CPUE) Mapping of species Evaluation of fish population status Trophic food web (see Prato et al., 2015) Socio-economic, cost-benefit analysis

Asterisks refer specifically to artisanal (*) or recreational fishing (**), while # refers particularly to on board or logbook information.

· <u>Mapping fishing activity (ArcGIS software)</u>: Bathymetry is a prerequisite layer for mapping fishing. It can be easily created through interpolation in ArcGIS using bathymetric lines and known depth points. Management and local regulations of the wider area are also necessary to set spatial rules (e.g. fishing closures). Information such as areas' acronyms, distance from coast, habitat and substrate type may increase mapping accuracy. Other tools may be useful in the case of information gaps, such as Google Earth for recreational fishing assists in the identification of areas with access from coast, authorized distance from coast (Giakoumi et al., 2013; Mazor et al., 2014), common depth technique is practiced (Markantonatou et al., 2014). In the case of point information (e.g. GPS, VMS/AIS[6], boat observers), the spatial deviation equal to 10% of the gear length ('buffer') should be drawn around the location of gear deployment accounting for uncertainty of fixed nets location (Stelzenmüller et al., 2008). In the case of fishing from coast, distance from coast is considered more accurate for mapping than depth (Markantonatou et al., 2014). Confidence levels are defined by assessing the quality and quantity of information following the precautionary principle.

Fishing effort per gear expressed as total number of hours per temporal unit (e.g. season or year) is suggested as the most appropriate indicator in order to characterize fishing pressure on benthic habitats and sea bottom (Fig. 2). Trends from past information may provide an additional indicator to inform decisions regarding the emergence of management response. Identification of metiérs may also be take place in this phase using spatial analysis tools (e.g. Tzanatos et al., 2013).

· Pressure assessment: Overlaying in ArcGIS the habitat map and fishing effort may identify areas that receive different levels of fishing activity. Vulnerable habitats receiving the highest fishing pressure may be defined as the ones receiving 90% of the total effort occurring for a specific fishing gear, as suggested by the Data Collection Framework (DCF) of the Common Fishery Policy (EC, 2008; EC, 2008).

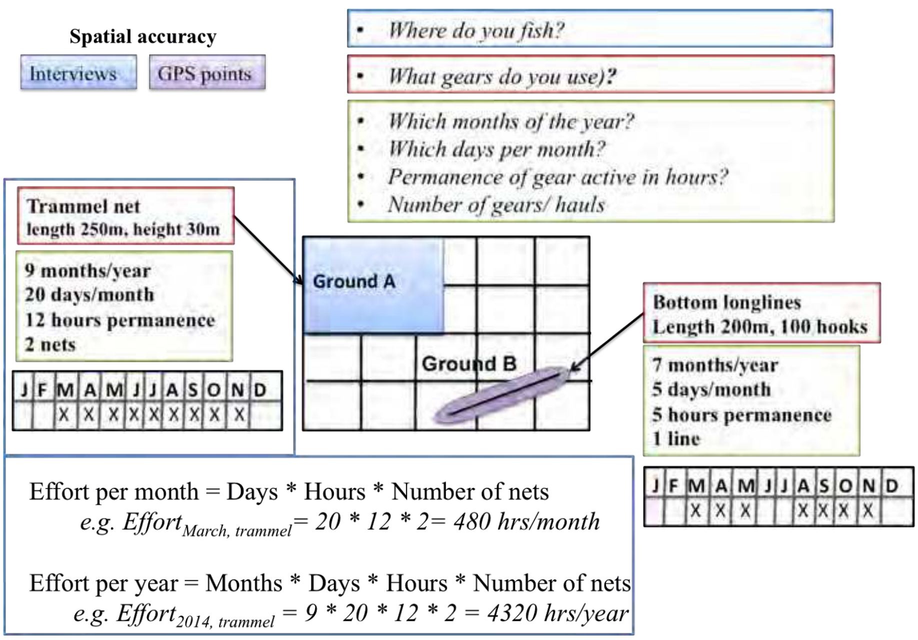


Fig. 2. Example of minimum information necessary for spatially allocating fishing activity. The difference in quality of information between area (interviews) vs. point information (e.g. GPS, VMS, boat observers) is also depicted.

· Capacity of geo-referenced fishing effort:

i. Risk assessment: the potential risk of degradation or loss of a vulnerable habitat considering the different level of impacts from fishing practices and the vulnerability of the habitat (amongst others Knights et al., 2015; Robinson et al., 2013).

ii. Verification of information, such as species distribution modelling, by catch and lost fishing gear (e.g. Markantonatou et al., in prep.)

iii. Bio-economic modelling finding optimal harvesting policy in combination with no-take MPAs, or exploring the implications for effort allocation (e.g. Briscoe et al. 2014; Torres et al., 2015)

iv. Cumulative impact assessments (Halpern et al., 2007)

v. Stock assessments and trophic food web modelling regarding the catch information (e.g. Prato et al., in prep.)

vi. Marine Spatial Planning and Systematic conservation planning: designing of MPAs and zoning plans with the least opportunity cost, examination of conservation targets reached (Marxan and Marxan with Zones software, Ball et al., 2009; Watts et al., 2009).

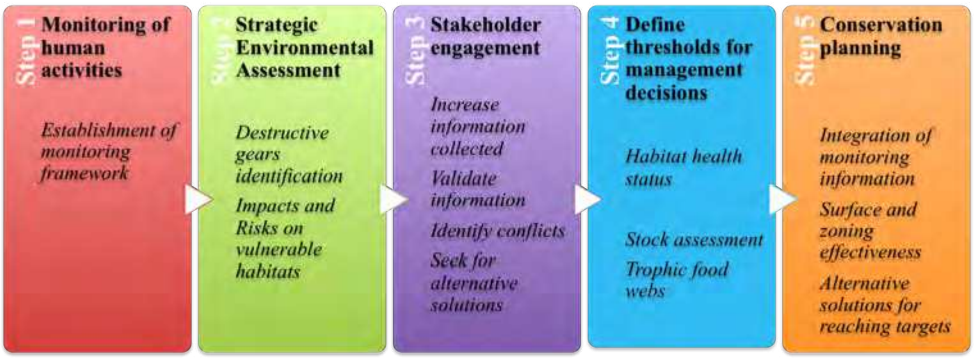


Fig. 3. Holistic framework for informing management decisions regarding fishing activity in MPAs.

2. Monitoring fishing activity in Portofino MPA (Ligurian Sea, Italy)

· Monitoring and mapping fishing effort: The MPA has been divided into 18 smaller management units. Information obtained by fishing diaries, boat observers and interviews mapping of 27 small-scale and 113 recreational fishermen that use tools potentially harmful for benthic habitats (period 2012-2014) was integrated and mapped in ArcGIS 10.2 as described above (Markantonatou et al., 2014 and references therein). Spatial accuracy of fishing activity was increased using interpolated bathymetry, common depth of each fishing practice, habitat and substrate type (Diviacco and Coppo, 2006), Google Earth, participatory maps and acronyms of areas. Fishing effort was calculated in terms of total hours per year.

· Spatial and temporal allocation of fishing effort: Artisanal fishing is rather limited but locally intensive on vulnerable habitats. The use of artisanal gears is highly seasonal with gillnets, combined nets and fishing cephalopods mostly employed during autumn. During spring and summer, use of trammel nets and longlines is increased. On the contrary, recreational activity is assessed as high with an increasing trend recorded since 2008 (Cappanera et al., 2012). October was the most popular month for recreational fishing.

· Pressure assessment: The coralligenous habitats are used as an example to describe the pressure assessment on vulnerable habitats present in a MPA. The analysis showed that the coralligenous habitats receiving maximum fishing activity are located at depths between 40-60m, with special reference to depths of 30-40 m at the southeastern part (management units 6- 11; Fig. 4). Recreational fishing with rod and bottom trolling, and professional gillnets and trammel nets mainly affect these areas. These results are verified by the multiple reports of human impacts and climate change that are subject to, such as lost fishing gear, necrosis and massive mortalities events reported on these habitats (Cattaneo-Vietti, R., personal communication; Cerrano et al., 2000; Vezzulli et al., 2013).

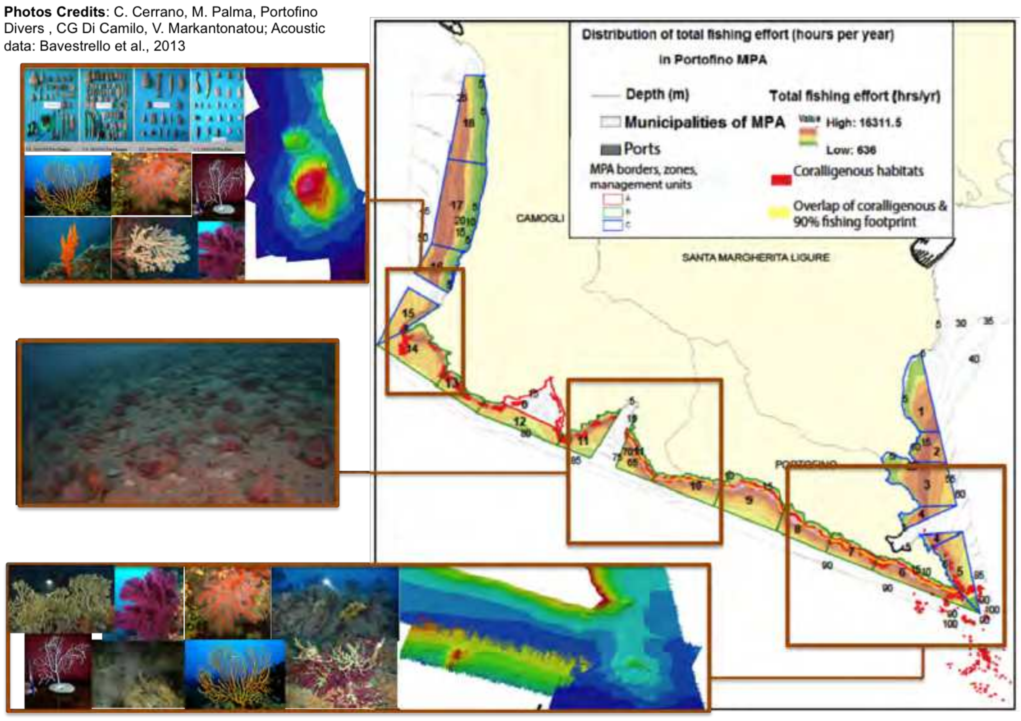


Fig. 4. Total fishing effort (hours per year) of fishing practices potentially harmful for benthic habitats in Portofino MPA. Photos present the most characteristic species of the habitat and severe pressures that are subject to. Red colour depicts the distribution of coralligenous communities, while yellow shows the coralligenous receiving the maximum fishing effort (90% of total effort). From Markantonatou et al., 2014

Management recommendations for Portofino MPA

- Discrimination of destructive gears in monitoring and accurate data providence is essential element to taking action (Markantonatou et al., 2014)
- Special care should be made regarding the southeastern part towards more strict regulations in order to limit destructive fishing practices in this area. Particularly the use of bottom longlines (100 hooks, directly target groupers) are in contrast with the MPA's regulation regarding maximum catch and prohibition of fishing *Epinephelous emarginatus*
- In the case of anomalous warm waters during the summer period, spatial and temporal closures from September is recommended. This action is expected to limit the likelihood of a mass mortality event on coralligenous, facilitated where organisms already presents injuries
- Adoption of online tools, VMS/AIS and consistent on-board observers may additionally increase monitoring efficiency (Markantonatou et al., 2013)
- Although currently divers collect lost fishing gears, consistent action should be implemented along with marking of nets (Markantonatou et al., in prep.)
- Regular meetings, awareness and trust-bonded relations with fishermen are expected to improve the quality of monitoring and reporting of lost gears
- Regular surveillance will assist in eliminating illegal fishing and could be combined with monitoring, especially in the case of recreational fishing
- Outcomes regarding holistic management decisions should be treated with caution, since the complete framework suggested in Fig. 3 has been partially applied

3. Conclusions

Understanding the spatial and temporal patterns of fishing effort is fundamental for the sound conservation of fish stocks, habitats and seafloor integrity, identification of conflicts and cumulative impacts in resource management. The present study provides a straightforward approach for monitoring and mapping spatial and temporal patterns of artisanal and recreational fishing activity. Simple spatial indicators and analyses are suggested in order to describe fishing pressure and identify areas that receive the greatest fishing effort. The approach integrates information originating from a range of monitoring strategies that may be adopted depending on the capacity of MPA management performance, and incorporates uncertainty regarding available information following the precautionary principle.

This is a generic framework for long-term monitoring that integrates powerful analysis and visualization, which may provide a holistic assessment and scientific advise towards ecosystem-based fisheries management. The guidelines correspond to a wide range of EU Directives, such as the Common Fishery Policy, the Marine Strategy Framework Directive and the Directive of Marine Spatial Planning, that promote the good environmental status of habitats and seafloor integrity and sustainable exploitation of marine resources. We suggest spatial pressure indicators, such as fishing effort, as useful and comprehensive tools that are easily communicated regarding fishing footprint on vulnerable habitats. They respond rapidly to ecosystem changes from human activities and management actions, can be monitored and measured precisely, and therefore may inform effectively decisions (Piet and Hintzen, 2012).

Our framework combines relatively low cost methods that can be progressively evolve along with the MPA management capacity, and is applicable to other ecosystems at any location. Long term monitoring and geo-referenced information regarding the species distribution and the health status of habitats may improve the quality of this analysis in order to assess the risk to and recovery of ecosystems from artisanal and recreational fishing activities on a scale relevant to support conservation objectives. This approach could also trigger an important participatory pathway, exploitable with different stakeholder. Finally the importance of local responsibility and surveillance in the area is highlighted as an important component to achieve win-to-win outcomes.

References

Ball, I.R., Possingham, H.P., Watts, M., 2009. Marxan and relatives: software for spatial conservation prioritisation, in: Moilanen, A., Wilson, K.A., Possingham, H.P. (Eds.), Spatial Conservation Prioritisation: Quantitative Methods and Computational Tools. Oxford, UK, pp. 185–195.

Bo, M., Bava, S., Canese, S., Angiolillo, M., Cattaneo-Vietti, R., Bavestrello, G., 2014. Fishing impact on deep Mediterranean rocky habitats as revealed by ROV investigation. BIOLOGICAL CONSERVATION 171, 167–176. doi:10.1016/j.biocon.2014.01.011

Briscoe, D.K., Hiatt, S., Lewison, R., Hines, E., 2014. Modeling habitat and bycatch risk for dugongs in Sabah, Malaysia. Endang. Species. Res. 24, 237–247. doi:10.3354/esr00600

Cappanera, V., Venturini, S., Campodonico, P., Blini, V., Ortenzi, C., 2012. Valutazione dell'impatto antropico sul sistema costiero, con particolare riferimento alla pressione antropica all'interno dell'Area Marina Protetta del Promontorio di Portofino. Portofino MPA.

Cerrano, C., Bavestrello, G., Bianchi, C.N., Cattaneo-vietti, R., Bava, S., Morganti, C., Morri, C., Picco, P., Sara, G., Schiaparelli, S., Siccardi, A., Sponga, F., 2000. A catastrophic mass‐mortality episode of gorgonians and other organisms in the Ligurian Sea (North‐western Mediterranean), summer 1999. Ecology Letters 3, 284–293. doi:10.1046/j.1461-0248.2000.00152.x

Diviacco, G., Coppo, S., 2006. Atlante degli habitat marini della Liguria. Centro Stampa Offset, Genova.

E.C., 2008a. Commission Decision of 6 November 2008 adopting a multiannual Community programme pursuant to Council Regulation (EC) No 199/2008 establishing a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy (2008/949/EC). O.J.E.U., L346.

EC, 2008b. Commission Regulation (EC) No 665/2008 of 14 July 2008 laying down detailed rules for the application of Council Regulation (EC) No 199/2008

concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy, O.J.E.U., L186.
Giakoumi, S., Sini, M., Gerovasileiou, V., Mazor, T., Beher, J., Possingham, H.P., Abdulla, A., Çinar, M.E., Dendrinos, P., Gucu, A.C., Karamanlidis, A.A., Rodic, P., Panayotidis, P., Taskin, E., Jaklin, A., Voultsiadou, E., Webster, C., Zenetos, A., KATSANEVAKIS, S., 2013. Ecoregion-Based Conservation Planning in the Mediterranean: Dealing with Large-Scale Heterogeneity. PLoS ONE 8, e76449. doi:10.1371/journal.pone.0076449
Gilman, E., 2015. Status of international monitoring and management of abandoned, lost and discarded fishing gear and ghost fishing. Marine Policy 60, 225–239. doi:10.1016/j.marpol.2015.06.016
Halpern, B.S., Selkoe, K.A., Micheli, F., Kappel, C.V., 2007. Evaluating and Ranking the Vulnerability of Global Marine Ecosystems to Anthropogenic Threats. Conservation Biology 21, 1301–1315. doi:10.1111/j.1523-1739.2007.00752.x
Knights, A.M., Piet, G.J., Jongbloed, R.H., Tamis, J.E., White, L., Akoglu, E., Boicenco, L., Churilova, T., Kryvenko, O., Fleming-Lehtinen, V., Leppanen, J.-M., Galil, B.S., Goodsir, F., Goren, M., Margonski, P., Moncheva, S., Oguz, T., Papadopoulou, K.N., Setälä, O., Smith, C.J., Stefanova, K., Timofte, F., Robinson, L.A., 2015. An exposure-effect approach for evaluating ecosystem-wide risks from human activities. ICES J. Mar. Sci. 72, 1105–1115. doi:10.1093/icesjms/fsu245
Markantonatou, V., Marconi, M., Cappanera, V., Campodonico, P., Bavestrello, A., Cattaneo-Vietti, R., Papadopoulou, N., Smith, C., Cerrano, C., 2014. Spatial allocation of fishing activity on coralligenous habitats in Portofino MPA (Liguria, Italy), in: Bouafif, C., Langar, H., Ouerghi, A. (Eds.). Presented at the UNEP/MAP- RAC/SPA, Proceedings of the second Mediterranean Symposium on the conservation of Coralligenous and other Calcareous Bio-Concretions. Portorož, Slovenia, 29-30 October 2014, Portorož, Slovenia, pp. 118–123.
Markantonatou, V., Marconi, M., Cerrano, C. Susceptibility assessment of seafloor to lost fishing gear in data poor areas. *In prep*
Markantonatou, V., Meidinger, M., Sano, M., Oikonomou, E., di Carlo, G., Palma, M., Ponti, M., Cerrano, C., 2013. Stakeholder participation and the use of web technology for MPA management. Advances in Oceanography and Limnology 4, 260–276. doi:10.1080/19475721.2013.851117
Mazor, T., Giakoumi, S., Kark, S., Possingham, H.P., 2014. Large-scale conservation planning in a multinational marine environment: cost matters. Ecological Applications 24, 1115–1130. doi:10.1890/13-1249.1
Piet, G.J., Hintzen, N.T., 2012. Indicators of fishing pressure and seafloor integrity. ICES J. Mar. Sci. 69, 1850–1858. doi:10.1093/icesjms/fss162
Prato, G., Gascuel, D., Francour, P., 2015. Guidelines for monitoring trophic relationships and ecosystem functioning in Mediterranean MPAs. MMMPA Deliverable.

Prato, G., Barrier, C., Francour, P., Cappanera, V., Markantonatou, V., Cappanera, V., Guidetti, P., Cattaneo-Vietti, R., Mangialajo, L., Gascuel, D. A trophic modelling approach to assess artisanal and recreational fisheries impacts and conflicts in MPAs, In prep

Robinson, L.A., White, L., Culhane, F., Knights, A.M., 2013. ODEMM Pressure Assessment Userguide V.2.

Stelzenmüller, V., Rogers, S.I., Mills, C.M., 2008. Spatio-temporal patterns of fishing pressure on UK marine landscapes, and their implications for spatial planning and management. ICES J. Mar. Sci. 65, 1081–1091. doi:10.1093/icesjms/fsn073

Tzanatos, E., Castro, J., Forcada, A., Matić-Skoko, S., Gaspar, M., Koutsikopoulos, C., 2013. A Métier-Sustainability-Index (MSI25) to evaluate fisheries components: assessment of cases from data-poor fisheries from southern Europe. ICES J. Mar. Sci. 70, 78–98. doi:10.1093/icesjms/fss161

Torres, L.G., Sutton, P.J.H., Thompson, D.R., Delord, K., Weimerskirch, H., Sagar, P.M., Sommer, E., Dilley, B.J., Ryan, P.G., Phillips, R.A., 2015. Poor Transferability of Species Distribution Models for a Pelagic Predator, the Grey Petrel, Indicates Contrasting Habitat Preferences across Ocean Basins. PLoS ONE 10, e0120014. doi:10.1371/journal.pone.0120014

Vezzulli, L., Pezzati, E., Huete-Stauffer, C., Pruzzo, C., Cerrano, C., 2013. 16SrDNA Pyrosequencing of the Mediterranean Gorgonian Paramuricea clavata Reveals a Link among Alterations in Bacterial Holobiont Members, Anthropogenic Influence and Disease Outbreaks. PLoS ONE 8, e67745. doi:10.1371/journal.pone.0067745

Watts, M.E., Ball, I.R., Stewart, R.S., Klein, C.J., 2009. Marxan with Zones: software for optimal conservation based land-and sea-use zoning. Environmental Modelling and Software 24, 1513–1521. doi:10.1016/j.envsoft.2009.06.005

[1] www.seasketch.org, McClintock lab, University of California Santa Barbara
[2] www.ecotrust.org
[3] www.donia.fr, Andromède Océanologie
[4] www.marinetraffic.org
[5] http://globalfishingwatch.org, Oceana
[6] Vessel Monitoring Systems (VMS) and Automatic Identification System (AIS)

Chapter IV Appendix

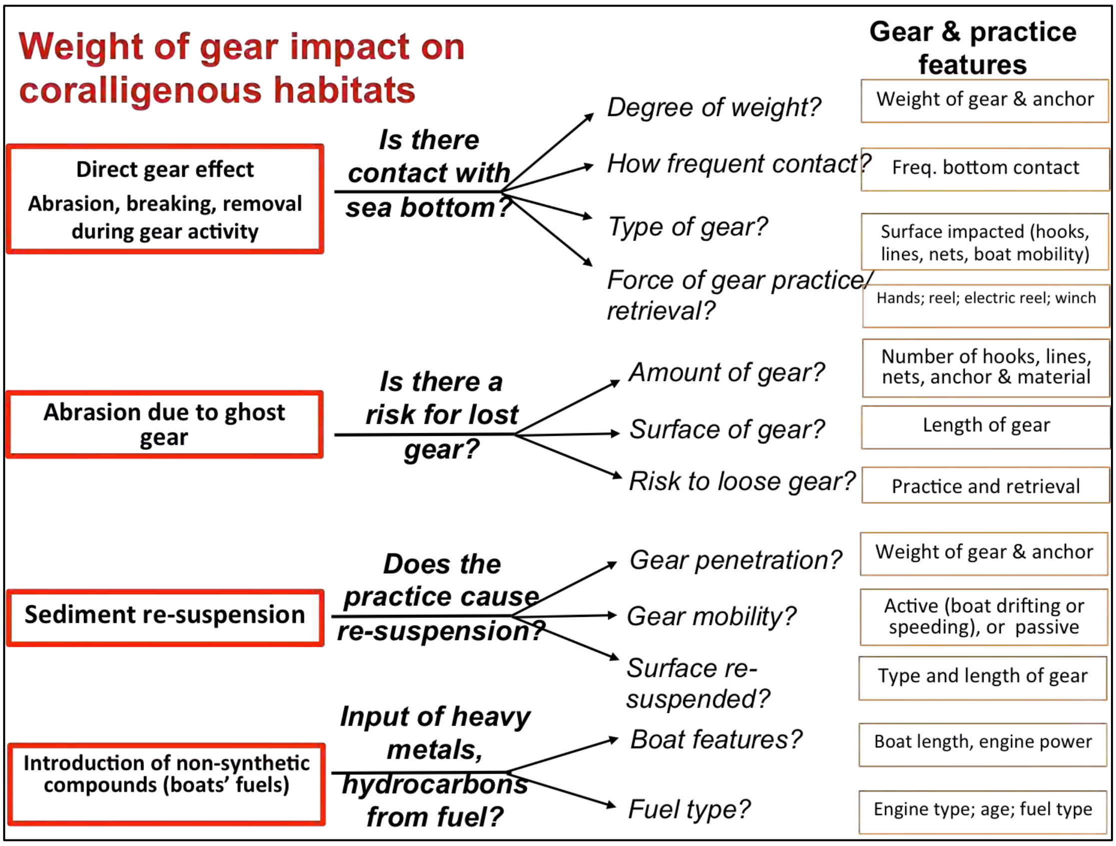


Figure 1: The conceptual framework and attributes used as surrogates for assessing vulnerability components

Table 1.
Ranks of vulnerability measures for impact assessment on benthic habitats.

Vulnerability measure	Category	Rank	Descriptive Notes
Scale (m^2) ***What is the scale of the threat impact?***	No threat	0	
	<1	1	
	1-10	2	
	10-100	3	
	100-1,000	4	
	1,000-10,000	5	
	>10,000	6	
Frequency ***What is the frequency of the impact?***	Never	0	
	Rare	1	Infrequent enough to affect long-term dynamics of a given population or location
	Occasional	2	Frequent but irregular in nature
	Annual or regular	3	Frequent and often seasonal or periodic in nature
	Persistent or permanent	4	More or less constant year-round lasting through multiple years or decades
Sensitivity ***How likely is that impact to affect the species in the affected benthic habitat?***	No impact	0	Unlikely to result in change in cover, density, abundance or community structure
	Low	1	Low likelihood of change in cover, density, abundance or community structure
	Low-Medium	2	Low- Moderate likelihood of change in cover, density, abundance or community structure
	Medium	3	Moderate likelihood of change in cover, density, abundance or community structure (33-66%)
	Medium-high	4	Moderate-High likelihood of change in cover, density, abundance or community structure
	High	5	High likelihood of change in cover, density, abundance or community structure
	Very High	6	Very high likelihood of change in cover, density, abundance or community structure
Recovery time (years) ***How long does it take to recover from exposure to the impact?***	No impact	0	
	<1	1	The population will take less than 1 year to recover
	1-10	2	The population will take between 1 and 10 years to recover

	10-100	3	The population will take between 10 and 100 years to recover.
	>100	4	The population/stock has no ability to recover and is expected to go "locally" extinct.
Certainty *How well are the impacts documented?*	None	0	
	Low	1	Very little or no empirical work exists
	Medium	2	Some empirical work exists or the expert has some personal experience
	High	3	Body of empirical work exists or the expert has direct personal experience
	Very high	4	Extensive empirical work exists or the expert has extensive personal experience

Table adapted by Giakoumi et al. (2015)

Table 2.
Examples of fishing practices and gears attributes practiced in Portofino MPA that were used to assess vulnerability scores

Fishing Technique	surface of gear in contact - Zone B	surface of gear in contact - Zone C	surface of gear in contact - Out MPA	Frequency of bottom contact	boat mobility	engine type (fuel)	engine power (KW o Hpa)	Gear component in contact with sea bottom and 3d structures	Probability of practice for lost fishing gear	Num. Hooks- Zone B	Num. Hooks- Zone C	Num. Hooks- Out MPA	Resistance_ Zone B	Resistance_ Zone C	Resistance_ OUT MPA	Num. Gears- Zone B	Num. Gears- Zone C	Num. Gears- Out MPA
Bottom trolling †	<1	<1	<1	Continuous	max 5-6 knotts	usually unleaded gasoline	44.292	weight (piombo; >3kgr)	Very low	2-3	2-3	2-3	hand	convent	convent	*2	*2	1-2
Pelagic trolling †	<1	<1	<1	No contact	max 5-6 knotts	usually unleaded gasoline	44.292	weight	No impact	2-6	2-6	2-6	hand	convent	convent	*2	*2	1-2
Fishing Cephalopods on boat †	<1	<1	<1	Occasionally	max 5-6 knotts	usually unleaded gasoline	32.702	lure (13-25gr); 16 hooks; weight 100-200	Medium- Low	6-12	6-12	6-12	hand	convent	convent	2	2	2
Bottom longlines †	1000	4000	4000	Continuous	boat drifting	usually unleaded gasoline	36.222	lines (mother, arms), hooks, anchors (2)	Very High	100	100	*50-200	hand	convent	convent	*1	*1	2-3
Pelagic longlines †	1000	4000	4000	No contact	boat drifting	usually unleaded gasoline	36.222	0	High	100	100	*50-200	hand	convent	convent	*1	*1	2-3
Vertical jigging †	1-10	1-10	1-10	Frequently	max 5-6 knotts	usually unleaded gasoline	61.111	lure (200gr.); possibly anchored	High	2-6	2-6	2-6	hand	convent	convent	1	1	1
Big game with rod †	<1	<1	<1	Continuous	boat drifting	usually unleaded gasoline	70.727	weight; sometimes hooks and lines-arms (depending on target species)	Very High	3	2-4	2-4	hand	convent	convent	*1	*1	1
Big game with hand †	<1	<1	<1	Continuous	boat drifting	usually unleaded gasoline	36.082	weight; sometimes hooks (depending on target species)	Very High	3	2-4	2-4	hand	reel	reel	*1	*1	1
Bottom fishing †	<1	<1	<1	Continuous	0		0	weight; sometimes a hook	Very High	3	3	3	hand	small reel	small reel	2	2	4
Rockfishing †	<1	<1	<1	Continuous	0		0	weight; sometimes lines and hooks	Very High	3	3	3	hand	reel	reel	2	2	2
Beach ledgering †	<1	<1	<1	Continuous	0		0	weight AND pasturatore; sometimes hooks	Very High	3	3	3	hand	reel	reel	2	2	4
Surfacasting †	<1	<1	<1	Continuous	0		0	weight; sometimes hooks	Low	3	3	3	hand	reel	reel	2	2	4
Fishing Cephalopods from coast †	<1	<1	<1	No contact	0		0	lure (13-17gr); 16 hooks; weight 100-200	Very low	3	12	12	hand	small reel	small reel	1	1	1
Drifting †	0	0	0	No contact	boat drifting	usually unleaded gasoline	40.091	0	Very low	1-3	1-3	1-3	hand	small reel	small reel			1
Natelli (drifting) †	0	0	0	No contact	boat drifting	usually unleaded gasoline	22.667	0	Very low	10	10	10 hooks	0	0	0	5	5	8
Galleggiante †	<1	<1	<1	No contact	0		0	hooks	Very low	1	1	1	hand	small reel	small reel	1	1	1
Spinning †	0	0	0	No contact	0		0	0	Very low	3	6	6	hand	reel	reel	1	1	1
Trammel/ Combined nets §	28090	28090	100000	Continuous	boat drifting	petrol	40.3	net; anchors (2)	Very High	530	530	1000	winch	winch	winch	3 nets	3 nets	3 nets
Gill nets §	23040	23040	100000	Occasionally	boat drifting	petrol	40	net	High	480	480	1000	winch	winch	winch	net	net	net
Bottom longlines §	4000	4000	100000	Continuous	boat drifting	petrol	32	lines (mother, arms), hooks, anchors (2)	Very High	*50-200	*50-200	100-1000	hand	winch	winch	*1	*1	2-3

Appendix

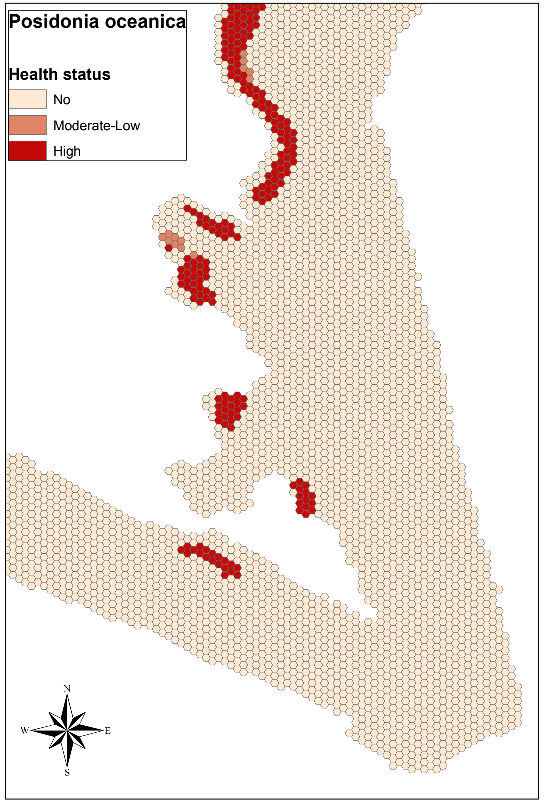
Table 1.
List of conservation features used in the analysis

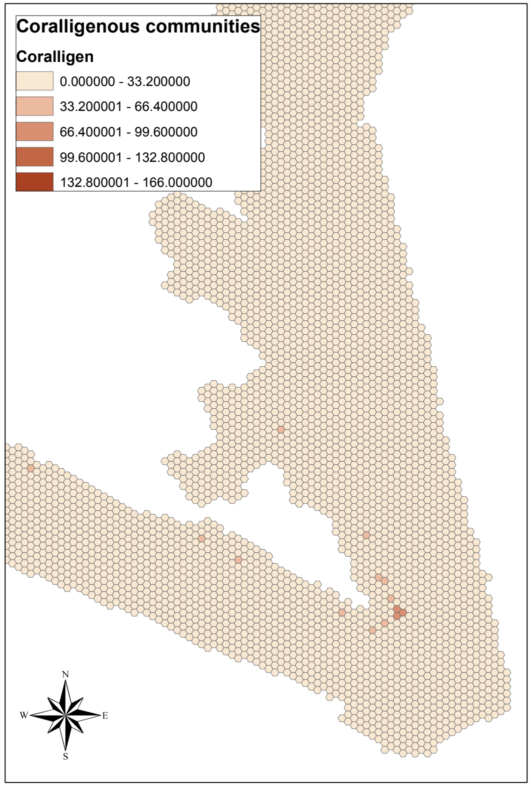
Feature type	Feature	Description	Units	Target level	Source extracted from
Habitat	*Posidonia oceanica*	Extracted from bionomic map, presence/absence	Health status (low, moderate, high)	0.6	Diviaco and Coppo, 2006-updated in 2012
Habitat	*Coralligenous habitats and underwater caves*	MAXENT model, Presence/absence, >75% probability of presence accepted	Spatial extend	0.6	Zapata et al., 2015a
Habitat	*Cystoseira amentacea var. stricta forests*	Abundance, health status	Health status (low, moderate, high)	0.6	Gianni and Mangialajo, 2015
Habitat	Infralittoral coarse sand	Extracted from bionomic map, presence/absence	Spatial extend	0.1	Diviaco and Coppo, 2006-updated in 2012
Habitat	Infralittoral photophilus algae	Extracted from bionomic map, presence/absence	Spatial extend	0.1	Diviaco and Coppo, 2006-updated in 2012
Habitat	Infralittoral sciaphilus algae	Extracted from bionomic map, presence/absence	Spatial extend	0.1	Diviaco and Coppo, 2006-updated in 2012
Fish	*Epinephelus marginatus*	MAXENT model, Presence/absence, >75% probability of presence accepted	Presence /absence in a PU	0.6	Zapata et al., 2014
Fish	*Sciaena umbra*	MAXENT model, Presence/absence, >75% probability of presence accepted	Presence /absence in a PU	0.3	Zapata et al., 2014
Fish	*Scorpaena sp.*	MAXENT model, Presence/absence, >75% probability of presence accepted	Presence /absence in a PU	0.1	Zapata et al., 2014
Fish	*Serranus sp.*	MAXENT model, Presence/absence, >75% probability of presence accepted	Presence /absence in a PU	0.1	Zapata et al., 2014
Morpho-sedimentary	Slope	Extracted from DEM with Benthic Terrain model	Mean	0.3	Zapata et al., 2015a
Morpho-sedimentary	Rugosity	Extracted from DEM with Benthic Terrain model	Mean	0.3	Zapata et al., 2015a
Morpho-sedimentary	Bank shelf		Spatial extend	0.1	Zapata et al., 2015a
Morpho-sedimentary	Shallow slope		Spatial extend	0.1	Zapata et al., 2015a
Morpho-sedimentary	Caves and overhangs		Spatial extend	0.1	Zapata et al., 2015a
Morpho-	Depression		Spatial extend	0.1	Zapata et al., 2015a

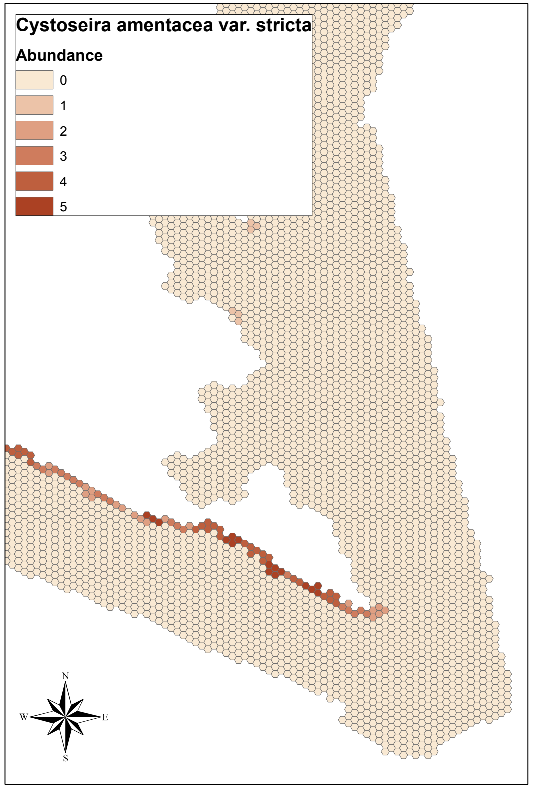
sedimentary				
Morpho-sedimentary	Upper slope	Spatial extend	0.1	Zapata et al., 2015a
Morpho-sedimentary	Lower bank shelf	Spatial extend	0.1	Zapata et al., 2015a
Morpho-sedimentary	Midslope	Spatial extend	0.1	Zapata et al., 2015a
Morpho-sedimentary	Bedrock	Spatial extend	0.1	Zapata et al., 2015a
Morpho-sedimentary	Rocky fall deposits	Spatial extend	0.1	Zapata et al., 2015a
Morpho-sedimentary	Silty sand	Spatial extend	0.1	Zapata et al., 2015a
Morpho-sedimentary	Sandy silt	Spatial extend	0.1	Zapata et al., 2015a
Morpho-sedimentary	Coarse sand	Spatial extend	0.1	Zapata et al., 2015a

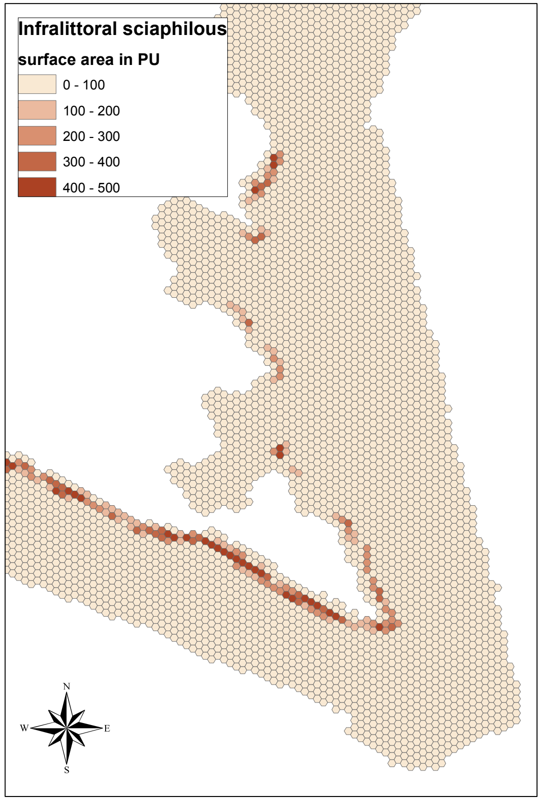
Table 2.
List of human activities and surrogates used in the analysis

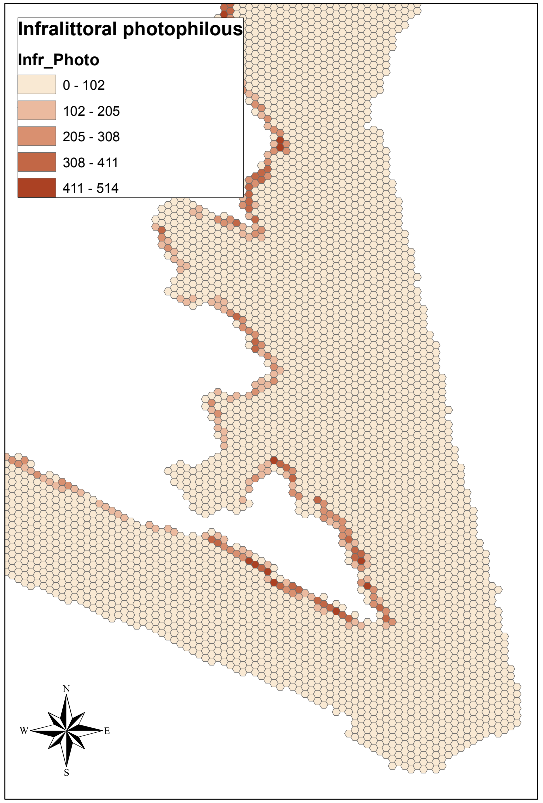
Feature type	Feature	Description	Units	Source
Human activity	*Artisanal fishing effort*	Includes longlines and nets	Sum of frequency (fishing days/year) per PU	Markantonatou et al., 2014 (updated in 2015) and references therein
Human activity	*Recreational fishing effort*	Including fishing practices that do not come in contact with seafloor (e.g. bottom trolling, vertical jigging, big game, bottom longlines, rockfishing)	Sum of frequency (fishing days/year) per PU	Markantonatou et al., 2014 (updated in 2015) and references therein
Human activity	*Diving effort*	Abundance, health status	Sum of frequency (dives/year) per PU	Portofino MPA logbooks

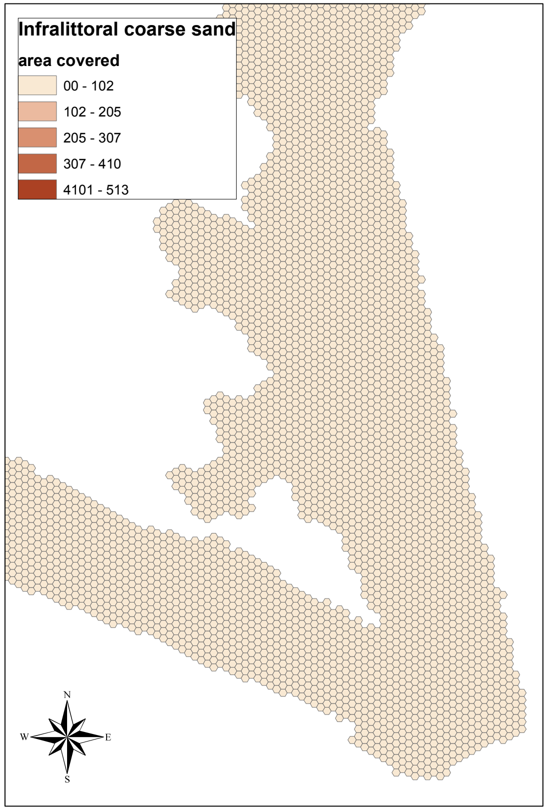

Posidonia oceanica
Health status
No
Moderate-Low
High
N
W
E
S

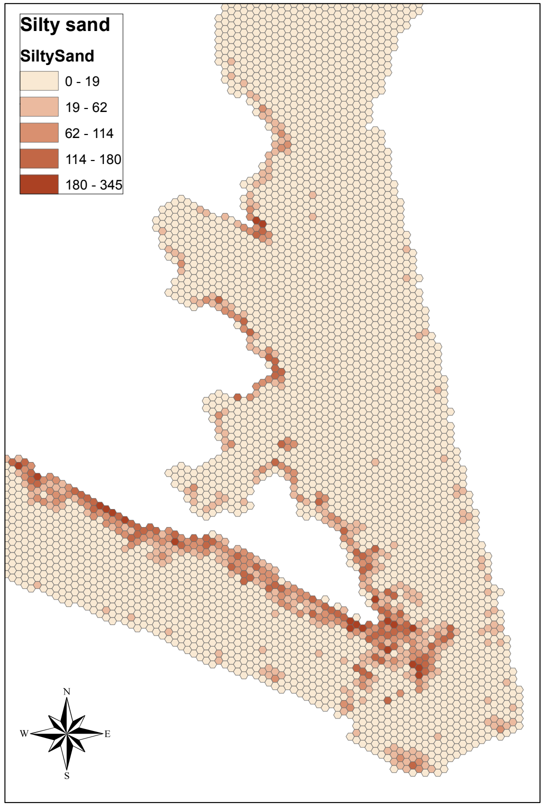

Coralligenous communities
Coralligen
0.000000 - 33.200000
33.200001 - 66.400000
66.400001 - 99.600000
99.600001 - 132.800000
132.800001 - 166.000000
N
W
E
S

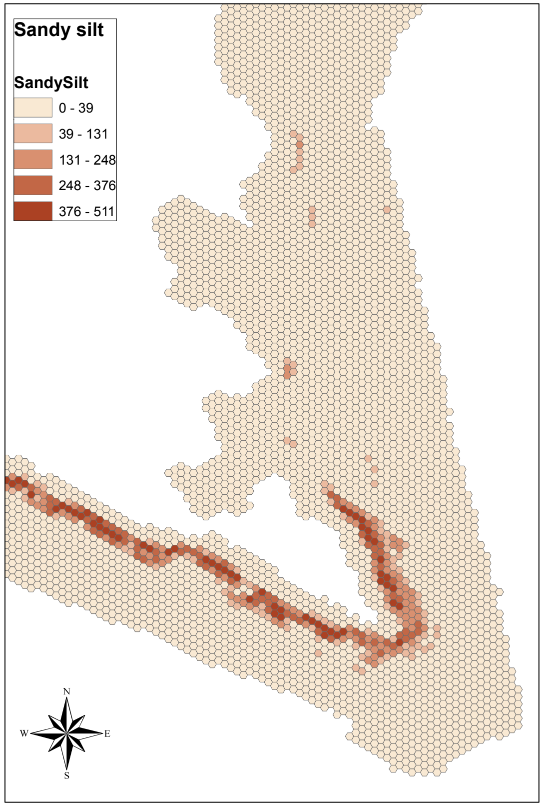

Cystoseira amentacea var. stricta
Abundance
0
1
2
3
4
5
N
W
E
S

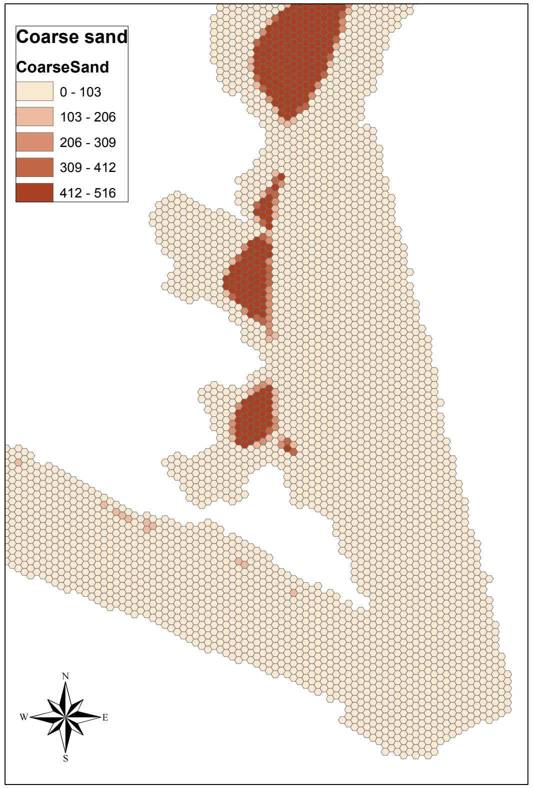

Infralittoral sciaphilous
surface area in PU
0 - 100
100 - 200
200 - 300
300 - 400
400 - 500
N
W
E
S

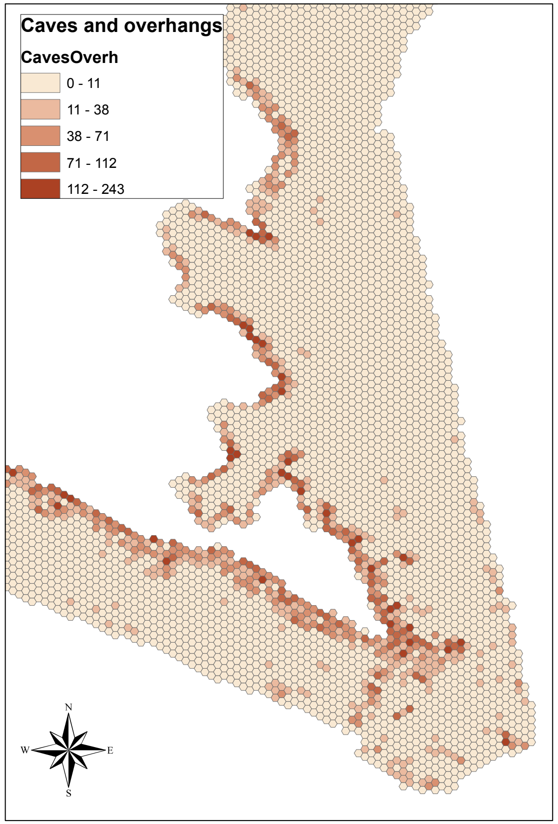

Infralittoral photophilous
Infr_Photo
0 - 102
102 - 205
205 - 308
308 - 411
411 - 514
N
W
E
S


Infralittoral coarse sand
area covered
00 - 102
102 - 205
205 - 307
307 - 410
4101 - 513
N
W
E
S

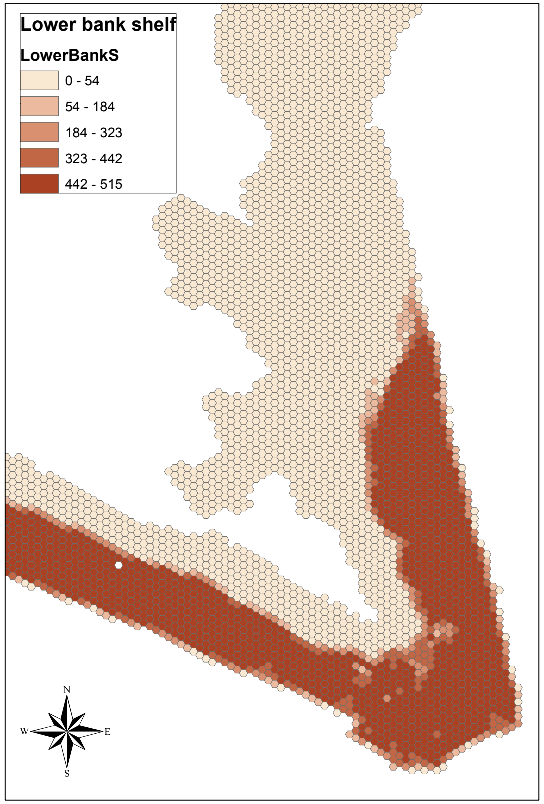

Silty sand
SiltySand
0 - 19
19 - 62
62 - 114
114 - 180
180 - 345
N
W
E
S

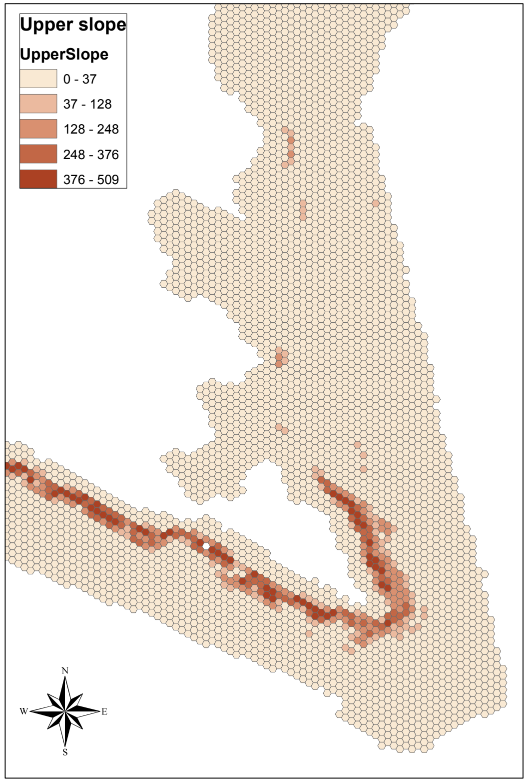

Sandy silt
SandySilt
0 - 39
39 - 131
131 - 248
248 - 376
376 - 511
N
W
E
S

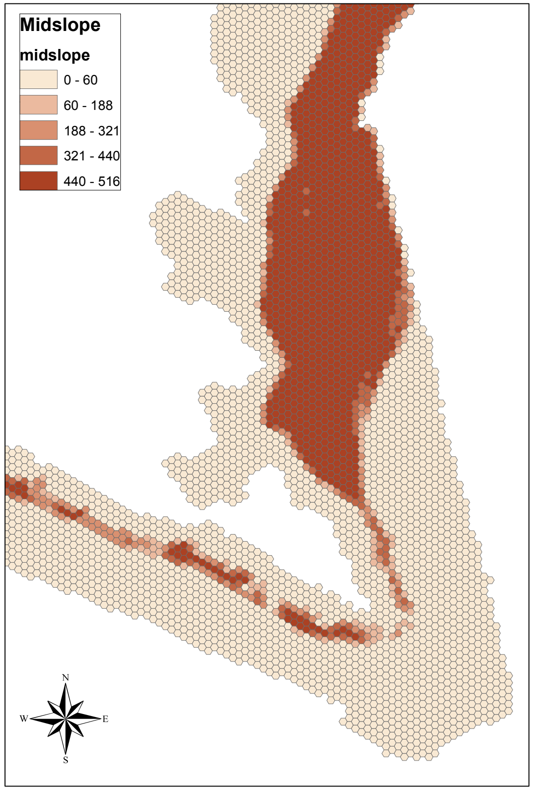

Coarse sand
CoarseSand
0 - 103
103 - 206
206 - 309
309 - 412
412 - 516
N
W
E
S

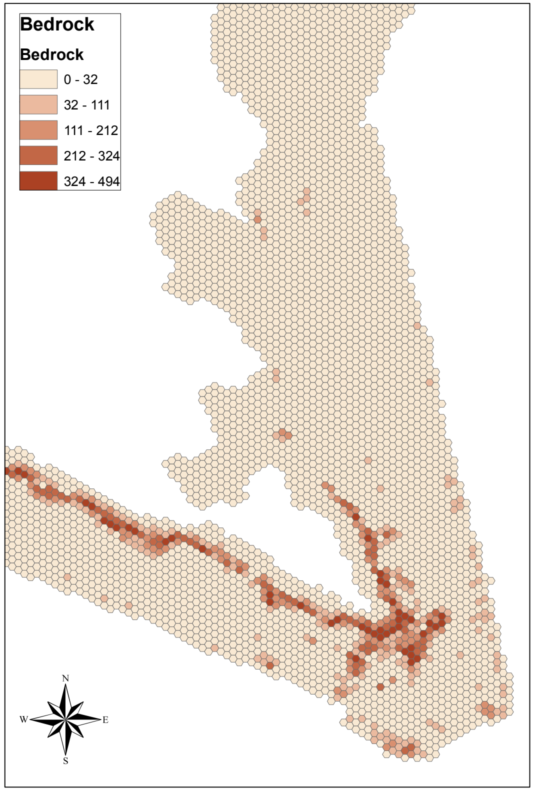

Caves and overhangs
CavesOverh
0 - 11
11 - 38
38 - 71
71 - 112
112 - 243
N
W
E
S

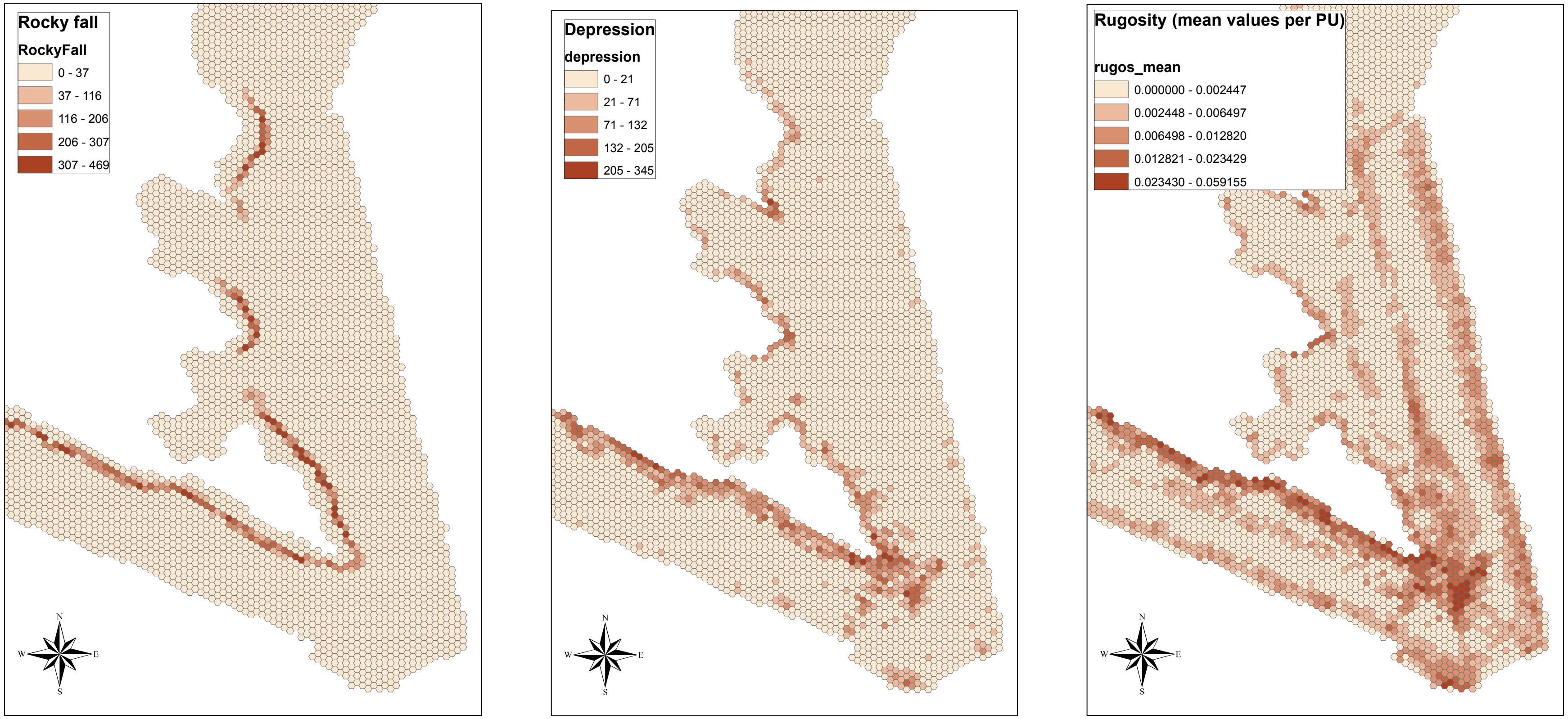

Bank shelf
BankShelf
0 - 34
34 - 112
112 - 200
200 - 310
310 - 500
N
W
E
S


Lower bank shelf
LowerBankS
0 - 54
54 - 184
184 - 323
323 - 442
442 - 515
N
W
E
S

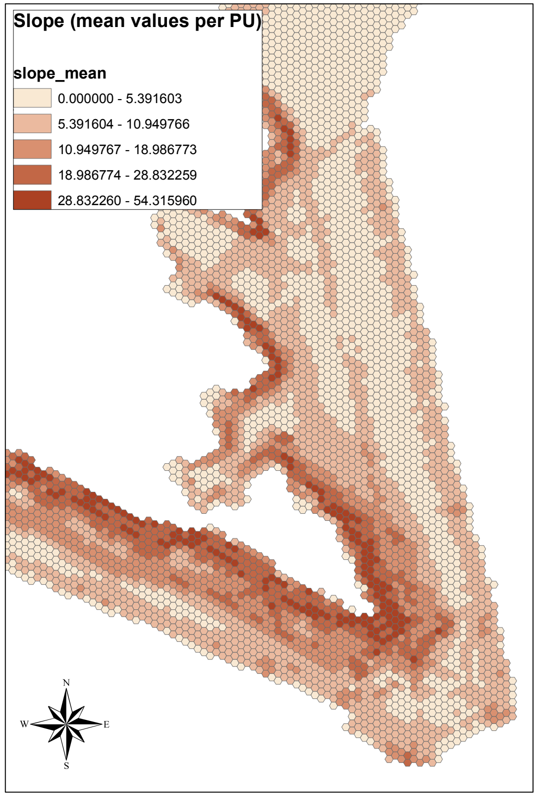

Upper slope
UpperSlope
0 - 37
37 - 128
128 - 248
248 - 376
376 - 509
N
W
E
S


Midslope
midslope
0 - 60
60 - 188
188 - 321
321 - 440
440 - 516
N
W
E
S

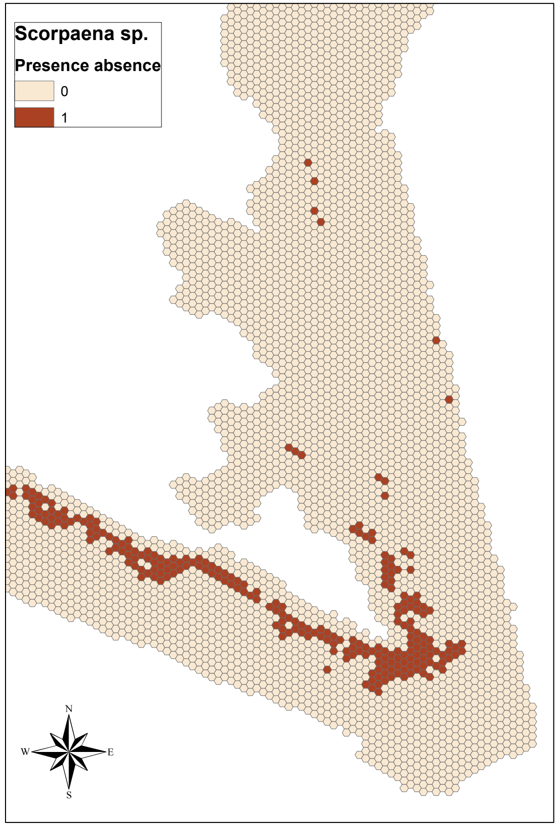

Bedrock
Bedrock
0 - 32
32 - 111
111 - 212
212 - 324
324 - 494
N
W
E
S



Rocky fall
RockyFall
0 - 37
37 - 116
116 - 206
206 - 307
307 - 469
N
W
E
S
Depression
depression
0 - 21
21 - 71
71 - 132
132 - 205
205 - 345
N
W
E
S
Rugosity (mean values per PU)
rugos_mean
0.000000 - 0.002447
0.002448 - 0.006497
0.006498 - 0.012820
0.012821 - 0.023429
0.023430 - 0.059155
N
W
E
S


Slope (mean values per PU)
slope_mean
0.000000 - 5.391603
5.391604 - 10.949766
10.949767 - 18.986773
18.986774 - 28.832259
28.832260 - 54.315960
N
W
E
S


E. marginatus
Presence absence
0
1
N
W
E
S


Scorpaena sp.
Presence absence
0
1
N
W
E
S

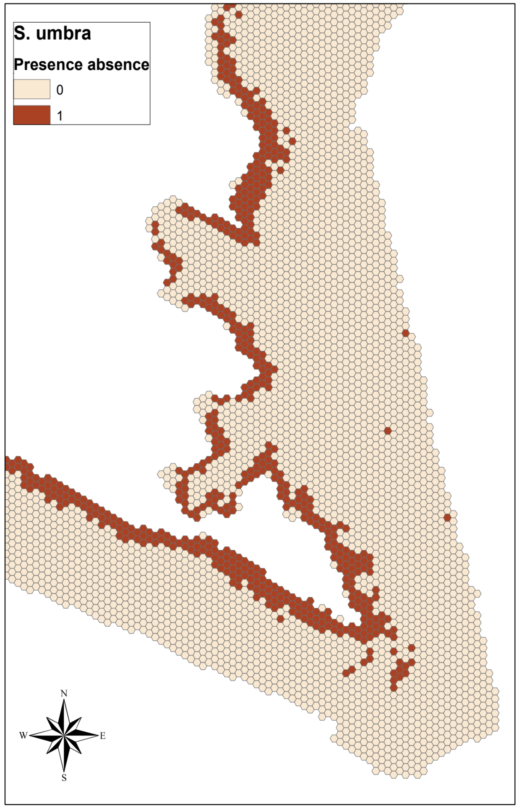
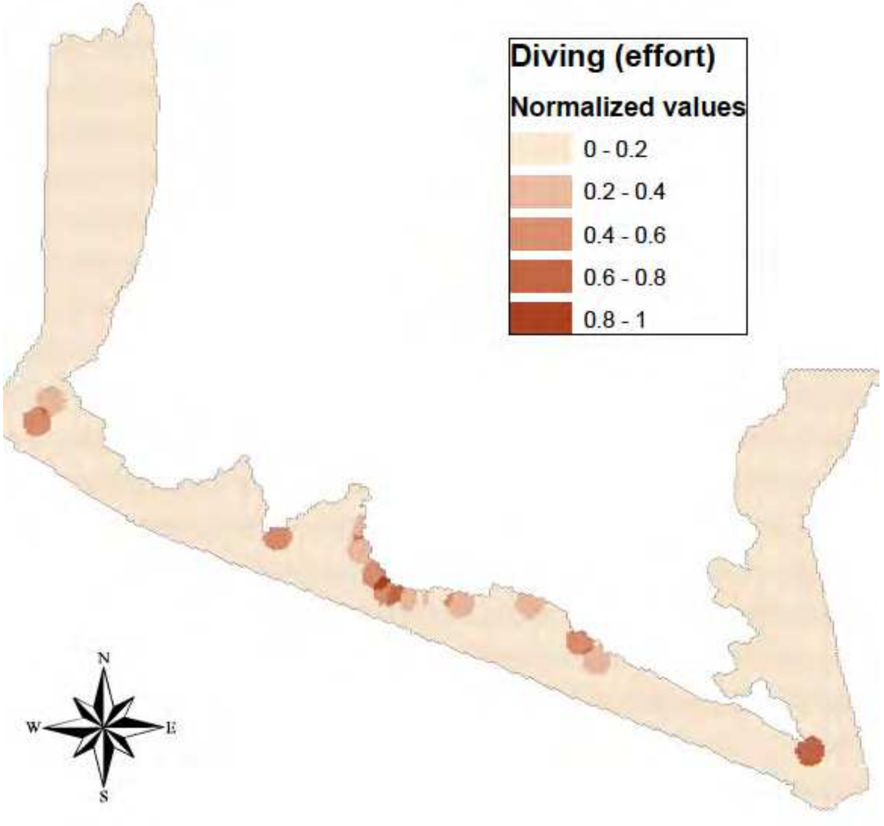
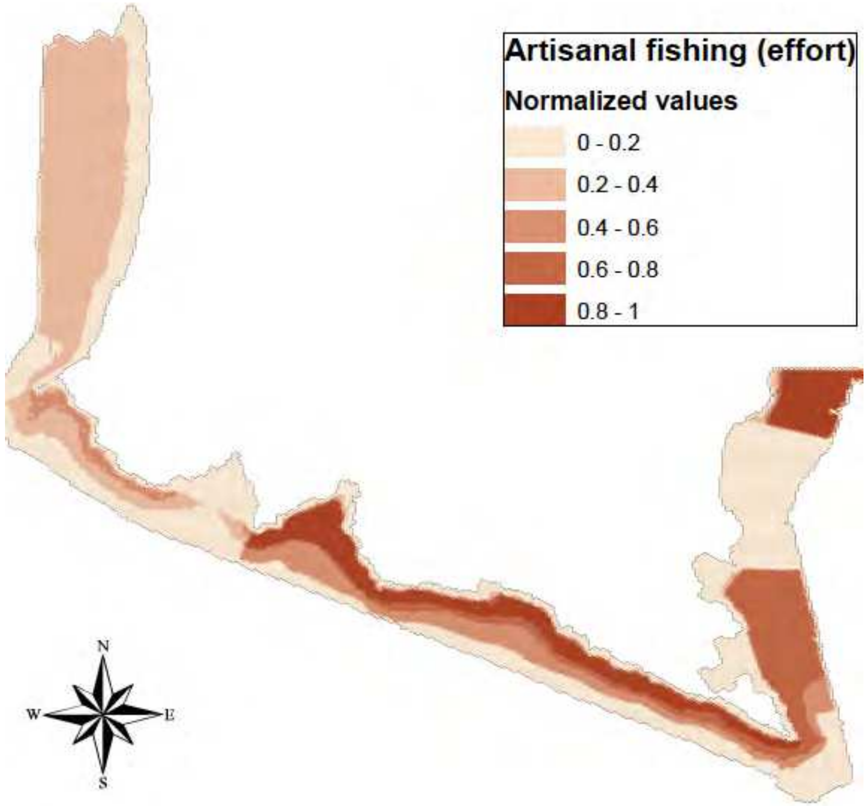


Fig. 1-22. Spatial distribution maps of conservation features incorporated in the conservation planning analysis


Diving (effort)
Normalized values
0 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
N
W
E
S


Artisanal fishing (effort)
Normalized values
0 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
N
W
E
S

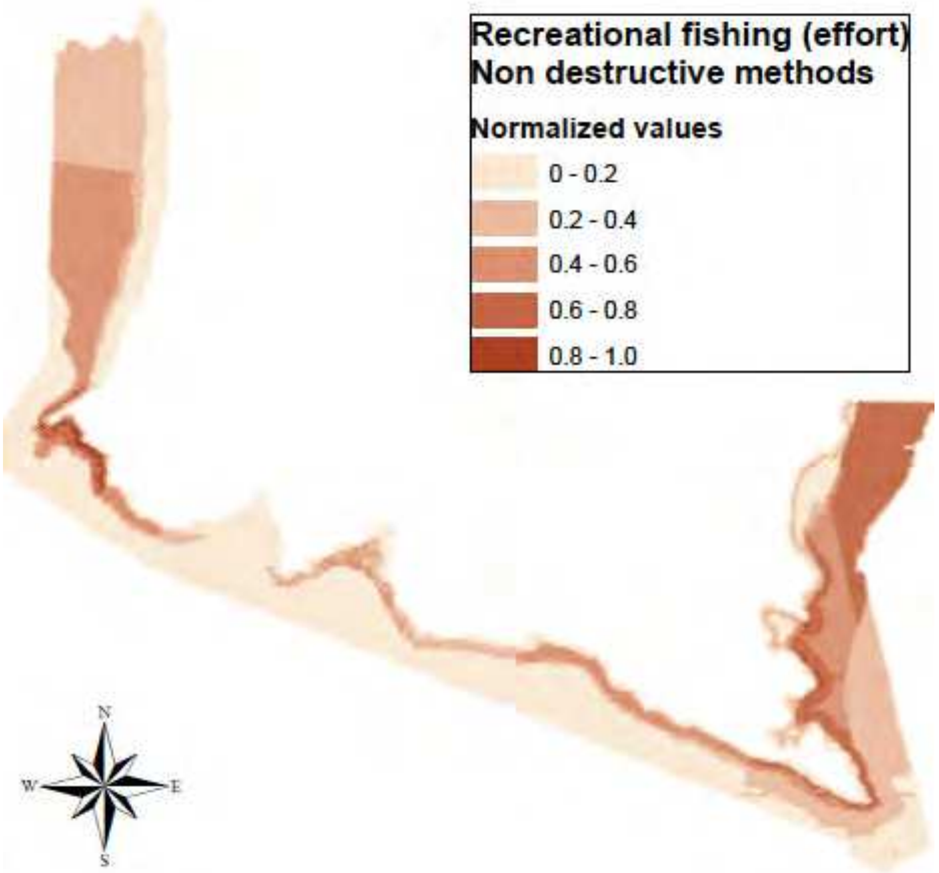


Fig. 22-25. Spatial distribution maps of socio-economic data ('opportunity costs') incorporated in the conservation planning analysis