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Research article

Improving marine protected area governance through collaboration and co-production

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ABSTRACT

Marine protected areas (MPAs) socio-ecological effectiveness depends on a number of management and governance elements, among which stakeholder engagement and community support play key roles. Collaborative conservation initiatives that engage stakeholders in action research and knowledge co-production processes can enhance management and governance of MPAs. To design effective strategies aimed at reconciling biodiversity conservation and management of sustainable human uses, it is key to assess how local communities respond to such initiatives and identify the set of contextual factors, institutional, local and individual, potentially affecting these responses. This paper presents the approach and results of one such initiative, spanning 6 EU countries and 11 MPAs in the Mediterranean Sea, focusing on small-scale fishers as key MPA users. Through a collaborative project, managers and fishers agreed upon specific governance interventions (e.g. increasing stakeholder engagement, engaging fishers in monitoring activities, reducing fishing efforts) to be implemented in each MPA for one year. Structured surveys queried: MPA managers on the MPA context, governance structure, feasibility and effectiveness of the tested interventions; and small-scale fishers on their perceptions of the impact of the tested interventions on a set of 9 socio-ecological variables (e.g. amount of fish caught, level of participation in decision-making, support for the MPA). Results revealed that the interventions tested were relatively feasible, effective and cost-effective. Fishers reported positive perceptions of the interventions for the 9 variables considered, especially for level of support for the MPA and for those associated with aspects of governance. Proportional odds models highlighted perceived effects are maximized under certain institutional, local and individual circumstances (e.g. old MPAs, small fisher communities, and fishers with a high proportion of income from fisheries). Findings highlight that employing good governance processes involving stakeholders may rapidly generate improved local support for conservation and provide insights for potential leverage points upon which to act to maximize perceived effectiveness and enhance support toward MPAs.

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1. Introduction

Marine protected areas (MPAs) are the most widely promoted spatially explicit conservation tool and policy solution to address many of the well-documented problems of marine habitat degradation and overfishing (Caveen et al., 2013). However, marine environments are highly complex and MPAs are found to vary significantly in their effectiveness. Many studies indicate that, when properly designed, funded, enforced, organised and managed, MPAs are able to provide a series of ecological benefits within their borders (namely the 'reserve effect') (Di Franco et al., 2018; Edgar et al., 2014; Giakoumi et al., 2017; Gill et al., 2017; Scianna et al., 2019), which can potentially lead to positive socio-economic effects in nearby areas (Di Franco et al., 2016; Hattam et al., 2014; Kerwath et al., 2013; Sala et al., 2013). However, there remains some debate as research has also shown that MPAs can be both an ecological success and a social failure (Chaigneau and Brown, 2016; Christie, 2004; Hogg et al., 2019). There remains considerable controversy over what makes MPAs successful and how they should be governed (Bown et al., 2013; Chuenpagdee et al., 2013; Jentoft et al., 2007; Jones et al., 2011).

MPAs can be viewed as complex social-ecological systems where humans and nature overlap and interact. When MPAs are created human activities and behaviours are directly curtailed or regulated, which can affect nearby communities and lead to local opposition. MPA conservation problems need to be examined hand-in-hand with social factors, including local livelihoods, values, interests and perceptions (Voyer et al., 2012). Yet, research on the human dimension and the social impacts of MPAs have been limited (Bennett, 2016; Bennett et al., 2017; Christie et al., 2017). Mounting evidence suggests that organisational and social factors determine the overall success or failure of a MPA, indicating the inherent need for increased consideration of the human dimension (Bennett et al., 2019, 2020; Blount and Pitchon, 2007; Chaigneau and Brown, 2016; Hogg et al., 2017b; Jentoft et al., 2012; Lubchenco and Grorud-Colvert, 2015; Mascia et al., 2010; Pollnac et al., 2010).

In addition to the failure to understand and incorporate the human dimension, MPA success has been found to be significantly hampered by governance shortcomings (e.g., lack of participation, inadequate communication and transparency) and capacity shortfalls (e.g., inadequate management processes, staff and budget capacity, and lack of enforcement) (Di Franco et al., 2016; Gill et al., 2017; Guidetti et al., 2008; Scianna et al., 2015). One response to addressing such shortfalls and the complexities associated with dynamic socio-ecological systems has been to increase stakeholder engagement, which aligns with a shift in marine conservation and governance towards more inclusive and participatory strategies (Freeman et al., 2018). Supporters of stakeholder participation claim that it facilitates representation of diverse views and values; provides local knowledge and solutions tailored to specific contexts and local needs; prepares the ground for more effective implementation of long-term management policies; legitimizes marine resource governance; and effectively develops individual learning capacities through action (Armitage et al., 2008; Berghöfer et al., 2008; Carlsson and Berkes, 2005; Hogg et al., 2017b; Nenadovic and Epstein, 2016).

Stakeholder participation and management insights can be facilitated through action research or knowledge co-production processes (Beier et al., 2017; Djenontin and Meadow, 2018; Norström et al., 2020; Rodela and Swartling, 2019). Conservation initiatives that encourage action research (research carried out by a team encompassing scientists and local actors, e.g. resource users, inhabitants of a defined area, etc., seeking to improve their situation, Cassell and Johnson, 2016; Greenwood and Levin, 2007) and knowledge co-production (Beier et al., 2017; Djenontin and Meadow, 2018; Norström et al., 2020; Rodela and Swartling, 2019) which directly involve scientists, local actors (e.g. resource users) and public managers and policy makers are increasingly being funded, developing participatory and capacity building initiatives that can better address some of the issues undermining biodiversity conservation and fisheries management (Chuenpagdee et al., 2010; Garcia and Charles, 2007; Leleu et al., 2012; Mackinson et al., 2011; Norström et al., 2020). In order to design effective strategies aimed at reconciling biodiversity conservation and management of sustainable human uses, it is important to assess how local communities respond to such knowledge co-production initiatives and identify circumstances that can make these initiatives successful.

Here we present the approach and results of one such initiative carried out between 2016 and 2019, spanning 6 EU countries and 11 MPAs in the Mediterranean region, encompassing a wide spectrum of governance systems, legislation schemes, MPA and small-scale fisheries (SSF) community characteristics. The aim of the initiative was to enhance MPA capacity; reconciling biodiversity conservation and SSF management, testing a series of interventions developed through a participatory approach with local actors. The initiative entailed a systematic approach (applied to 11 case study MPAs) which went a step beyond the business as usual approach to conservation. The process was designed to ensure that: local actors were involved; interventions met local needs; and the process and outcomes of the initiative were evaluated (i.e. the success or failure of interventions was tested in each MPA, and level of perceived support for the interventions was examined).

The current study aims to contribute to the growing literature on participatory initiatives and the important role of perceptions in understanding local actors support for conservation by: 1) providing a descriptive analysis of the governance-intervention approach implemented; 2) examining how the interventions tested may have improved perceived MPA socio-ecological effectiveness and specifically affected local actor support toward MPAs; and 3) assessing which elements (institutional and individual) can affect stakeholder perceptions of effectiveness of implemented interventions. We hypothesise that the governance intervention process applied can improve perceptions of ecological and social factors even in such a short timeframe (~1 year) and, through the participative process, generate increased support for the MPA and its governance.

2. Methods

2.1. Geographical context

The Mediterranean Sea is a highly valued and diverse inland sea, yet among the most heavily degraded, with presence of invasive species and human pressures such as pollution, resource exploitation, tourism and extraction continually increasing (Coll et al., 2011; Micheli et al., 2013). Estimates from 2017 suggest that 78% of fish stocks are harvested at biologically unsustainable levels (FAO, 2018). An estimated 86,500 fishing vessels operate in the Mediterranean and Black Sea, directly employing about 240,000 people on board vessels and contributing $2.8 billion in landed value (FAO, 2018). Small-scale fisheries represent 84% (70,000 vessels) of the fleet in the Mediterranean and Black Sea, employing 60% (150,000) of all fishers in the region, and producing 26% of total fishery revenue (FAO, 2018).

In 2016, there were a total of 1,215 MPAs covering 6.81% of the Mediterranean Sea (MedPAN, 2019), by 2019, 9.68% of the Mediterranean Sea had been designated as MPAs (Gomei et al., 2019). Most of the surface covered is located in the Western Mediterranean, with the majority of these in EU waters. Yet only 2.48% of MPAs have a management plan, 1.27% are effectively implementing these plans and only 0.03% of the Mediterranean is covered by fully-protected areas (Gomei et al., 2019). MPAs in the Mediterranean generally follow a centralised form of governance (yet there is some movement towards co-management) (Hogg et al., 2013), often enforcement is weak and they are characterised by a lack of financial and staff capacity (Scianna et al., 2018). In general, studies into the human dimension of MPAs in the Mediterranean are missing, and the social dimension is not regularly monitored by MPA managers as part of their plan or strategy (Hogg

et al., 2017a, 2017c; Scianna et al., 2018).

In this study small-scale fishing communities were investigated, operating inside or close to 11 EU MPAs in 6 countries: Telašćica Nature Park (Croatia), Nature Reserve of Bouches de Bonifacio, Cap Roux Fishing Reserve and Côte Bleue Marine Park (France), Zakynthos National Marine Park (Greece), Egadi Islands MPA, Portofino MPA and Torre Guaceto MPA (Italy), Strunjan Landscape Park (Slovenia), Cabo de Palos-Islas Hormigas Marine Reserve of Fisheries Interest and Es Freus D'Evissa I Formentera Marine Reserve of Fisheries Interest (Spain) (Fig. 1) (from here on MPAs are referred to by the underlined part of their name).

2.2. Governance-intervention approach

Twelve interventions believed to benefit SSF management within and around MPAs, broadly divided into 5 governance categories (involvement in decision making; enforcement strengthening; knowledge and ownership; improvement of SSF environmental sustainability; and improvement of SSF profitability, see Fig. 1) were identified through a preliminary study in 2015–2016 (Bennett et al., 2019; Di Franco et al., 2016). Here we focused on small-scale fishers as key users of MPAs, and SSF as an activity potentially promoting sustainable local economies that benefit from MPAs (Claudet and Guidetti, 2010; Di Franco et al., 2016; Guidetti and Claudet, 2010). The present study (2016–2019) tested these interventions in 11 MPAs, to quantify and assess the effectiveness in achieving socio-ecological benefits. The governance intervention approach adopted followed the same systematic sequence in each MPA (see Fig. 2) which created: MPA profiles allowing needs to be identified (collected through questionnaires administered to MPA managers in March 2017 and complemented with a literature review) (Step 1); a stakeholder engagement process through the establishment of a Local Governance Group (LGG) in each MPA, involving fishers in the decision-making process, ensuring local MPA needs were better understood through sharing of more diverse points of view (Note: in some MPAs fishers were already part of the MPA management committee) (Step 2); prioritisation of MPA needs, selection of governance interventions through participatory processes seeking consensus in each LGG and implementation of selected interventions (Step 3); and closure of the project and assessment of the successes and challenges of the interventions tested (Step 4) (access https://doi.org/10.6084/m9.figsh

THEME	INTERVENTION	THEME	INTERVENTION
INVOLVEMENT IN DECISION MAKING	1. Create collaborative platforms to engage fishers in decision	IMPROVE SSF ENVIRONMENTAL SUSTAINABILITY	7. Reduce fishing effort 8. Modify/substitute fishing gears 9. Set-up SSF Code of conduct
ENFORCEMENT STRENGTHENING	2. Increase surveillance by MPA staff and improved infrastructure 3. Increase surveillance through fishers' direct involvement 4. Increase surveillance through the cooperation with relevant authorities	IMPROVEMENT OF SSF PROFITABILITY	10. Add value to local fisheries products 11. Promote new commercial species 12. Support Pescatourism
KNOWLEDGE & OWNERSHIP	5. Engage fishers in monitoring activities 6. Raise the awareness of fishers, MPA managers and local communities		

Fig. 1. Map of MPA case studies. For each MPA circles represent the governance interventions selected by the relative Local Governance Group (LGG): colours indicate the governance categories in which interventions have been clustered, numbers represent the specific intervention implemented. Legend at the bottom details the interventions. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Fig. 2. Collaborative governance-intervention approach followed by the 11 pilot MPAs.

are.12144789.v1 for: project deliverables including the document created at the beginning of the project containing all the MPA profiles; and the reports describing the specific process followed by each LGG). After the period of implementation of the interventions, managers were asked to rate, on a 3-point scale (from 1 = low to 3 = high), the performance of interventions tested using three different indicators: economic affordability, immediacy of implementation and stakeholder participation required. Closure meeting minutes and notes were analysed and feedback on the interventions extracted to provide a tentative guide on the overall effectiveness of each implemented tool (on a 3-point scale low-high). This information was used to generate a set of web plots, that provide a simple visualization of strengths and weaknesses of the governance categories and each individual intervention.

2.3. Assessment of perceived socio-ecological effectiveness of interventions

To assess the perceived socio-ecological impacts of the governance interventions implemented, a questionnaire was administered to small-scale fishers a year after the start of their implementation. Fieldwork was carried out in each MPA between June–July 2018, with interviews conducted with 120 small-scale fishers (54.3% of all fishers operating within the selected MPAs) in 10 of the 11 MPAs (for details about numbers of fishers interviewed per MPA see Supplementary Materials, Table SM1). Respondents were mostly targeted through purposive, opportunistic and snowball sampling (Bryman, 2012) ensuring a representative proportion of each community (i.e. the fishers operating within and/or around each MPA) was interviewed (≥27% of all fishers in each MPA). Three of the 120 fishers did not wish to respond to the questions about the perceived socio-ecological impacts of the governance interventions. These interviews were maintained in the sample but due to the lack of some data could not be included in all the analyses that follow. During this fieldwork period fishers from Bonifacio declared to MPA staff that they were involved in too many projects and suffering interviewer fatigue, a common concern for projects and social researchers (Bryman, 2012). They elected not to respond to the final questionnaire, however participated fully in all previous activities related to the project, i.e. implementing and testing the governance interventions.

Fishers were asked if they had awareness of the initiative and governance interventions tested. This allowed assessment of whether fishers beyond those directly involved in the LGG were well informed. Following this, they were asked to rate their opinion, on a 5-point Likert scale from very negative to very positive impact, on 9 statements related to the impact/potential impact of each intervention on a set of variables describing MPA socio-ecological effectiveness: 1) the abundance of fish in the MPA; 2) the quality or health of habitats in the MPA; 3) the amount of fish that small-scale fishers can catch; 4) the income of small-scale fishers; 5) the relationships between MPA managers and small-scale fishers; 6) the level of conflict between small-scale fishers and other users in the MPA; 7) the participation of small-scale fishers in decision making processes; 8) the level of illegal fishing or poaching activities within the MPA; and 9) the support of small-scale fishers for the MPA (Supplementary Materials, Table SM2). Surveys were designed by the project team, shared with project partners for feedback, translated into local languages, pilot tested for layout and question comprehension, amended and approved in their final version by the project steering committee. Prior to being asked for verbal consent and proceeding with the survey, small-scale fishers and MPA managers were informed about the purpose of the survey and the intended use of the data, how data would be stored and treated anonymously and confidentially. To account for the 6 languages each MPA community had a dedicated individual to conduct interviews. Survey administrators received training and continuous assistance from the project team and followed a protocol on how to administer the survey, aiding consistency in all the MPAs.

2.4. Data analysis

Descriptive tables were used to examine demographics and characteristics of small-scale fishers. Small-scale fishers' perceptions about the effect of the interventions on the 9 socio-ecological variables (Supplementary Materials, Table SM2) from the 10 MPAs were analysed at the level of single MPAs to explore potential variability among-MPAs and represented through intervention-specific pie-chart maps. The data was then plotted on a Likert plot (ranging from least-most potential benefit) to highlight regional patterns. The results for the nine different variables were summed to create a single composite perception score capturing the overall effectiveness of the governance interventions. The sum was normalized and rounded on a scale from 1 to 10. Before summing the single items, internal coherence of the items in each scale was made using Chronbach's alpha co-efficient. No issue with internal coherence was highlighted for any of the 9 items (always >0.7). To identify potential predictors of perceived socio-ecological effectiveness of the implemented interventions, perceptions about effects of the governance interventions and the composite perception score were tested against a set of variables including: a) demographic characteristics at the scale of fisher (age, education level and proportion of household incomes deriving from SSF); b) individual perceptions of MPA governance (extent to which decision-makers consider fishers' point of view and needs); and c) characteristics at the location level (MPA age, presence of single/multiple villages in each fishers community and overall size of fishers community). Drivers of perceptions were investigated through a model-selection approach (see Supplementary Materials, Text SM1 for modelling details). Given that single response items were recorded as ordered categorical variables (on a scale from 1 to 5), analysis was carried out using proportional odds models, implementing in R the function 'clm' of the 'ordinal' package (Christensen, 2018). A single model was run for 7 of the 9 perception items (perceptions on 'habitat' and 'catch' were not considered for collinearity issues, see Supplementary Materials Figure SM1) and for the composite score. Following analysis of collinearity, the predictor 'Extent to which decision-makers consider your (fisher) needs' was dropped for redundancy (Supplementary Materials Figure SM 2). Model outputs were presented as odds ratio (OR) and relative confidence intervals (CI). All analyses were conducted in R environment (R Core Team, 2018).

3. Results

3.1. MPA management and governance features

The survey conducted with MPA managers (step 1) highlighted that the set of 11 MPAs selected included a wide range of management contexts. MPAs differed in terms of: surface area, zoning schemes, enforcement strategies, governance type, interaction with stakeholders (especially fishers), management needs and activities; and several organizational characteristics such as the structure of the management authority, and the presence of, style and detail in management plans (Table 1). On engagement with fishers all MPA managers reported some degree of interaction: 54.5% (6) reported a bidirectional interaction (i.e. where fishers and the MPA management body are able to express their own views and ideas); in one case the MPA management body reported a proactive interaction where fishers/their representatives actively propose and organise meetings; in the remaining MPAs (36.6%: 4) informal or unidirectional interactions were reported, with fishers simply being informed once management decisions were taken. On the number of meetings and fishers' attendance, 63.6% (7) reported 1–2 meetings a year are held, and fishers' attendance varied relatively evenly across all categories. The majority of managers (72%: 8) reported an overall staff shortfall to manage the MPA. All MPAs declared that the annual MPA budget was insufficient for all management needs. On enforcement operated by MPA personnel, one management body (9%) does not perform surveillance activities (Cap Roux), 4 (36%) perform interpretative/educational enforcement, and 6 (54%) performed both interpretative/educational and legal enforcement. Managers declared that the biggest shortfalls were enforcement, outreach programs (found to be very limited or absent in most of the cases, 9: 81.8%), and stakeholder engagement. See Supplementary Materials Text SM2 for an extended description of the results.

3.2. Selected governance interventions and feasibility

On which management interventions to implement, all LGGs selected engagement of fishers in decision-making, and 10 selected interventions to improve enforcement (Figs. 1 and 3 for details on the interventions). Improving fishers' engagement in decision-making included actions to increase the number of MPA meetings held and strengthening fishers' organisations through Fishers Local Action Groups (FLAGs). In one pilot site (Egadi Islands) fishers created and signed a voluntary code of conduct for small-scale fishers within the MPA. Overlapping with fishers' engagement in decision-making were actions to improve enforcement through fishers' direct involvement, and to improve knowledge and awareness by involving fishers directly in MPA monitoring. Several MPAs committed to address capacity shortfalls in enforcement, by using the project funds available to improve the infrastructure and train staff to better enforce fisheries regulations. Capacity building focused on ensuring MPA staff had legal authority to issue sanctions to transgressors. One LGG selected to install a state-of-the-art video surveillance system that would provide wide coverage of the MPA day and night. All actors were committed to this plan, however unforeseen bureaucratic and legislative challenges significantly delayed the process. In terms of cost, feasibility, level of stakeholder engagement required, and overall perceived effectiveness, the closing meetings and interviews with MPA managers revealed that engaging fishers in decision-making required low financial investment, a medium investment of time yet the impact was perceived to be very high (Fig. 3). Similarly, interventions tested to increase enforcement capacity were rated as having medium cost, longer time requirements and depending on which intervention, medium to high involvement from stakeholders, with a high impact expected/perceived. No interventions were expected or perceived to have low impact (Fig. 3).

Table 1
Summary information of MPA characteristics (see Supplementary Materials Text SM2 for additional details).

MPA	Country	Area (km^2)	Established	Zoning (NT = no-take, PP = partially protected)	Management authority	Number of meetings with fishers per year	Fishers attendance to meetings %	Management Plan
Egadi Islands MPA	Italy	540	1991	NT and PP	Local	1 to 2	0–25	Implemented
Portofino MPA	Italy	3.46	1999	NT and PP	Local	3 to 5	25–50	Implemented
Torre Guaceto MPA	Italy	22	1991	NT and PP	Local	>5	50–100	Implemented Includes a section for SSF management
Cabo de Palos-Islas Hormigas Marine Reserve of Fisheries Interest	Spain	19.3	1995	NT and PP	National + Regional	1 to 2	25–50	Implemented
Es Freus D'Evissa I Formentera Marine Reserve of Fisheries Interest	Spain	150	1999	NT and PP	Regional	1	0–25	Implemented
Cap Roux Fishing Reserve	France	4.45	2003	NT	Local	3 to 5	50–100	Implemented
Cote Bleue Marine Park	France	100	1982	NT	Local	1 to 2	50–100	Implemented Includes a section for SSF management
Nature Reserve of Bouches de Bonifacio	France	800	1999	NT and PP	Local	1 to 2	0–25	Implemented Includes a section for SSF management
Strunjan Landscape Park	Slovenia	1.14	1990	NT and PP	Local	0	0	Prepared but not implemented yet
Telašćica Nature Park	Croatia	70	1988	NT and PP	Local	1 to 2	50–100	Implemented
Zakynthos National Marine Park	Greece	83.3	1999	NT (only for 6 months) and PP	Local	1 to 2	50–100	Prepared but not implemented yet

3.3. Small-scale Ffishers survey sample and perceived socio-ecological outcomes

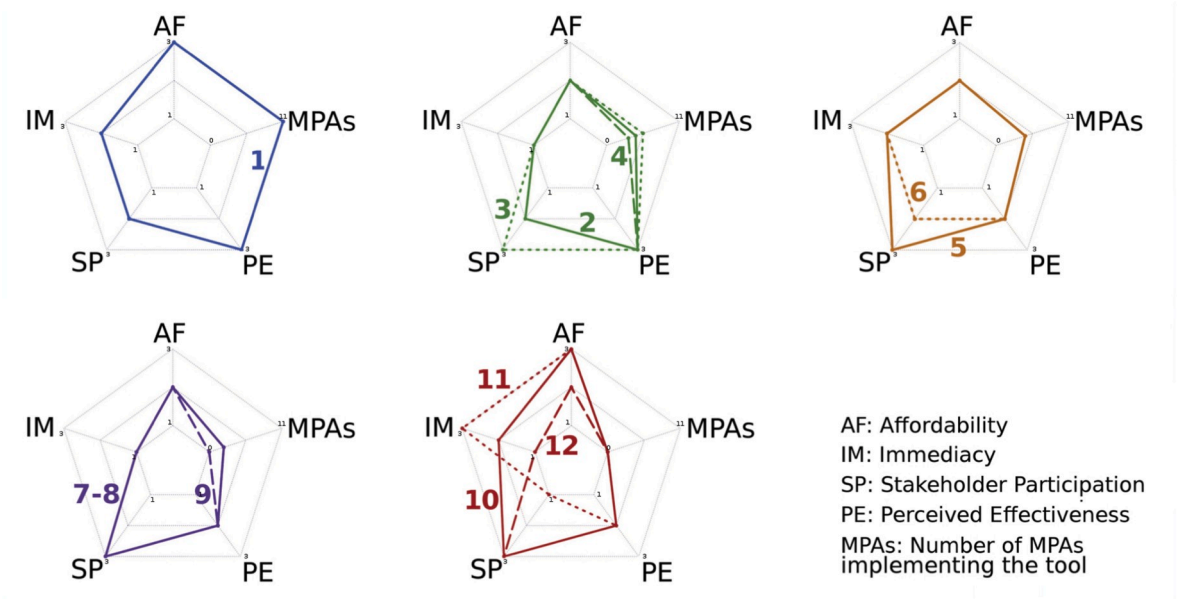
All 120 survey respondents were male small-scale fishers, mainly coming from the local villages/towns or the nearby area of each MPA. More than half of fishers were older than 50 years (Supplementary Materials, Table SM3). The majority of respondents had a middle school (39%) or elementary school degree (35%). Households were often composed by two (28%), three (24%), or four (28%) people, with 1 or 2 of them employed and contributing to the total household income. Only 32% of the respondent's family incomes were derived solely from small-scale fishing.

On awareness of the management interventions, survey results revealed that 85.5% of fishers knew about the interventions being tested. On the potential effects of governance interventions implemented, considering all the responses pooled together, 54.2% of fishers perceived positive effects, while very few fishers perceived that the implemented interventions were having or will have negative effects (6.8%) on the socio-ecological variables considered (Fig. 4, Supplementary Materials Table SM4 and SM5).

Concerning the amount of fish that small-scale fishers can catch, 57% stated that the interventions tested in the toolkit can produce positive or very positive benefits. Concerning both the abundance of fishes and the health of habitat in their MPA, 58.1% of fishers stated the new interventions adopted were producing or will produce positive or very positive effects. Concerning the level of conflicts between fishers and other MPA users, 60% of fishers stated that the governance interventions implemented in their MPAs were not (or will not) providing any benefits on reducing conflict with other users. On the potential effects on illegal fishing or poaching activities within the MPA the results were more heterogeneous with 23% perceiving negative effects, 30% neutral and 47% perceiving a positive or very positive effects. Thirty-five percent of fishers perceived a positive or very positive impact on their income, while 40% of fishers perceived no impacts (neither positive nor negative). The two questions concerning the potential benefits of the governance interventions on fishers' participation in decision-making and the relationship with MPA managers revealed that the majority of fishers (64.1% and 67%, respectively) agreed that the new governance interventions were or can provide positive benefits on these two aspects. Besides these general patterns it is interesting to highlight that responses were heterogeneous among MPAs, with some cases where responses were generally all skewed toward positive perceptions (e.g. Torre Guaceto), while others showing greater variability within the community (e.g. Cabo de Palos) (Fig. 5, and please see Supplementary Materials, Text SM3 for more detail on individual MPAs).

Finally, 74.6% believed the governance interventions are improving support for the MPA. Concerning the composite score, although variable among MPAs, an overall slight positive trend was highlighted (mean = 5.9 ± 0.13, Fig. 4). It is noteworthy that there was also a significant proportion of respondents in the neutral range, perhaps due to the short-time frame since the interventions were implemented.

Proportional odds models highlighted that perceptions on the effect of the interventions on "the abundance of fish" were significantly affected by the 'proportion of household income derived from SSF' with positive perceptions more likely with higher proportion of income from SSF (Fig. 6 details odd ratio and confidence intervals for each significant predictor). The same predictor was found to positively and significantly affect perceptions on the effect of interventions on fishers' incomes. Concerning the perceptions on the effect of the interventions on the relationship between fishers and MPA managers, perceptions were found to be significantly and more positively correlated with increasing age of the MPA, increasing consideration of fishers' point of view in decision-making and for MPAs that span multiple villages. These perceptions were found to be negatively affected by increasing overall size of the fisher community. The size of the community was also the only significant factor to affect the perceptions on the effects of the interventions on the level of conflict between small-scale fishers and other users in the MPA, i.e. the larger the community of fishers, the more likely are negative perceptions about the effect of interventions on the level of conflicts. No factors significantly relate with the effect of the governance interventions on the participation of small-scale fishers in decision-making. Perceptions on intervention effects on the level of illegal fishing or poaching activities within the MPA were positively related to MPA age, while negatively by the overall size of the SSF community. The same pattern was observed for the perception of intervention effects on the support of small-scale fishers for the MPA, found to be more positive



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KNOWLEDGE & OWNERSHIP	5. Engage fishers in monitoring activities 6. Raise the awareness of fishers, MPA managers and local communities		

Fig. 3. Web-plots showing, on a 1 (low) to 3 (high) scale, the economic affordability (AF), immediacy of implementation (IM), level of stakeholder participation (SP) as rated by MPA managers, perceived effectiveness (PE) as rated by small-scale fishers, and the number of MPAs (from 0 to 11) implementing each intervention (counter-clockwise from the top vertex of the pentagon respectively). Colours represent governance categories. Different line types (whole, dashed, dotted) are used to distinguish the different interventions along with the numbers which represent the specific interventions reported in the table. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

with increasing MPA age and negative with increasing SSF community size. The level of consideration of small-scale fishers' point of view by decision makers also positively related to the perceived support for the MPA. Finally, the composite score was significantly positively related with the age of the MPA and the proportion of income deriving from SSF while was negatively related to the size of the community (see Supplementary Table SM6 for the full summary of the models).

4. Discussion

This research provides a multi-site study of a governance-intervention approach, quantifying the perceived socio-ecological impacts of conservation interventions by small-scale fishers. Our study builds on previous literature examining perceptions of conservation, that have mostly used qualitative methods based on individual case studies (Bennett, 2016; Bennett et al., 2019). It extends previous conservation work and research employing a participative governance-intervention approach, to examine how participation in decision-making can affect perceptions and MPA support. Overall, results show that small-scale fishers are interested in increasing their level of engagement in decision-making and in other activities related to compliance and management (such as surveillance and monitoring) in MPAs. Previous evidence highlighted that perceptions of ecological effectiveness, social impacts, and good governance are drivers of local support toward MPAs (Bennett et al., 2019). Our findings suggest that perceptions of these elements can be enhanced through a participative governance-intervention approach. This change is a process as situations and perceptions continually evolve; however, it is a positive sign that within a relatively short time period (~1 year) we can see progress has been made. While small-scale fishers perceived positive effects for all the socio-ecological variables considered, it was those mostly associated with relationships with management, participation in decision-making and overall MPA support that revealed the most positive perceptions for potential/real impact. The perceived potential or real benefits associated with ecological and economic factors (e.g. abundance of fishes, habitat health, availability of fish to catch and fishers' income) were more varied, given that biological results from protection take a significant amount of time (5 years plus) (Claudet et al., 2008; Edgar et al., 2014). The timespan of the initiative is insufficient to expect

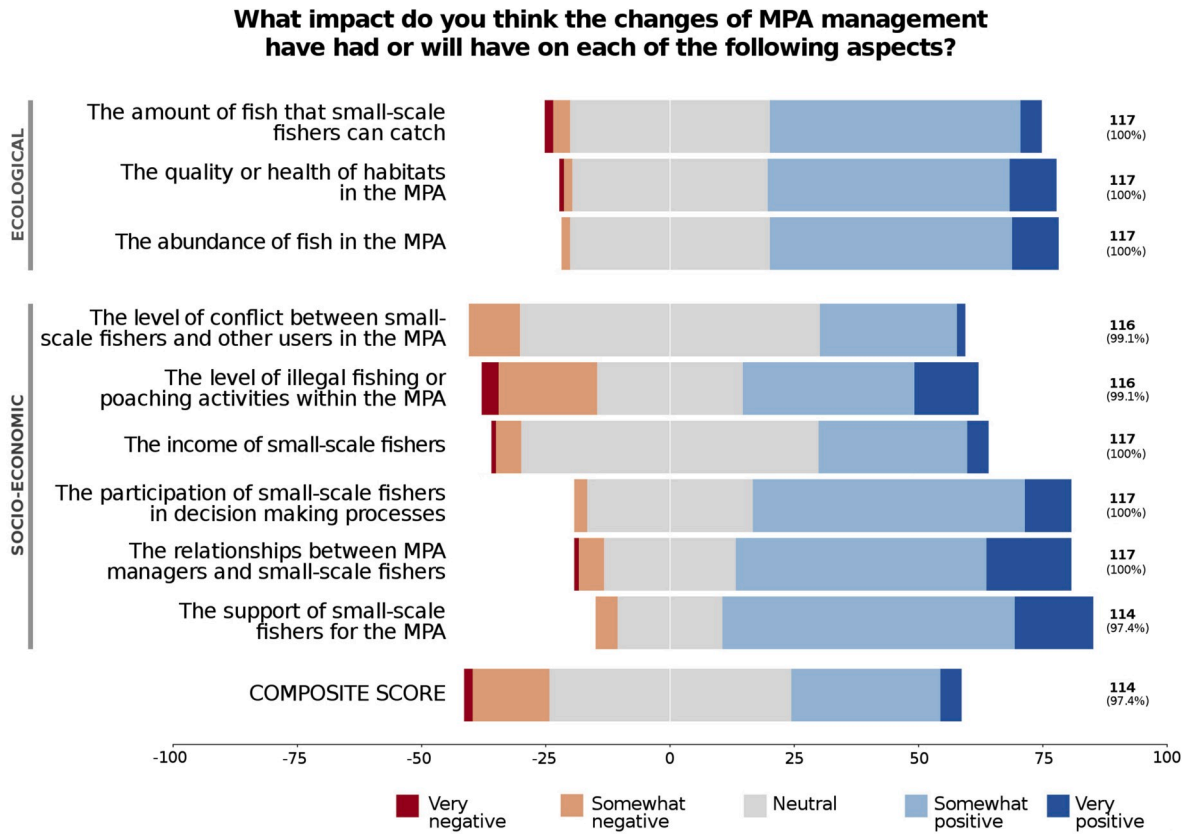

Fig. 4. Likert stacked bar-chart of fishers' perceptions regarding the potential impact the interventions had or will have on different aspects reported on the left. Within the two categories of perceptions (ecological and socio-economic), items are ordered from the most negative to the most positive. Composite score rescaled from 1 to 5 scale for visualization purposes. Absolute number of respondents for each statement and %'s of the total interviewed population are reported on the right.

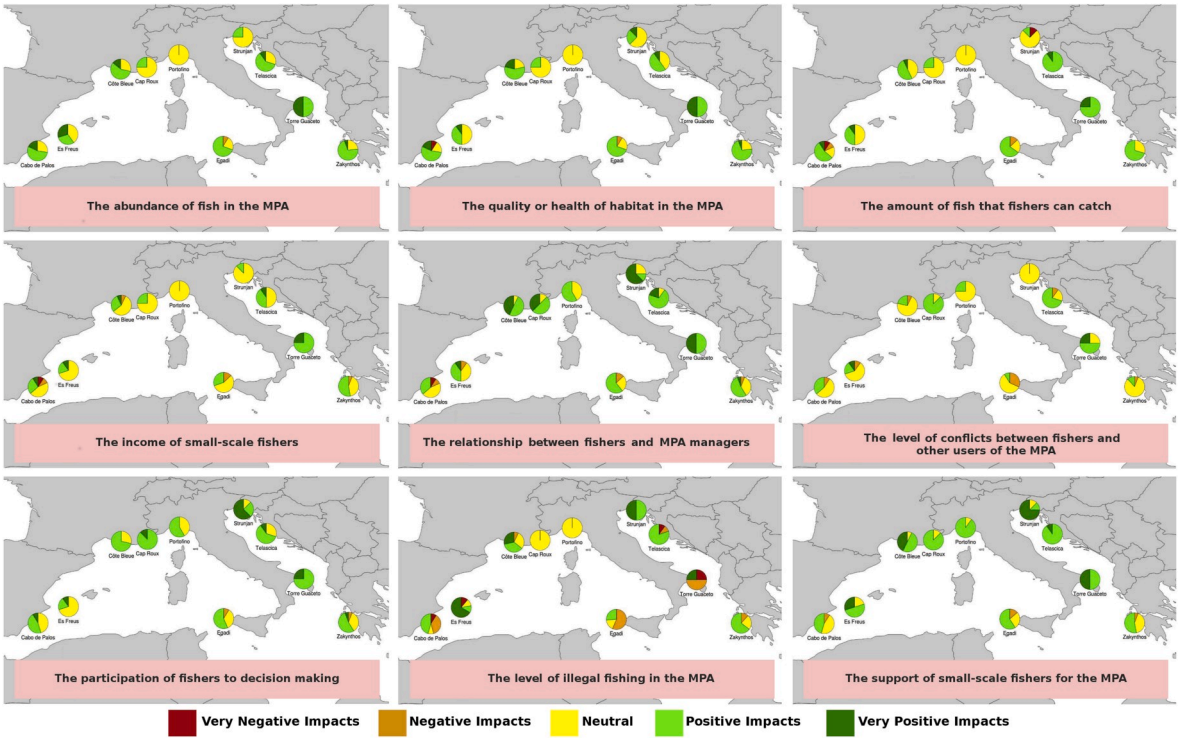

Fig. 5. Detailed perceptions for each MPA about the effects of the governance tools on each one of the aspects considered. Each aspect is represented by a map. Please see Supplementary Materials, Text SM3 for more detail on individual MPAs.

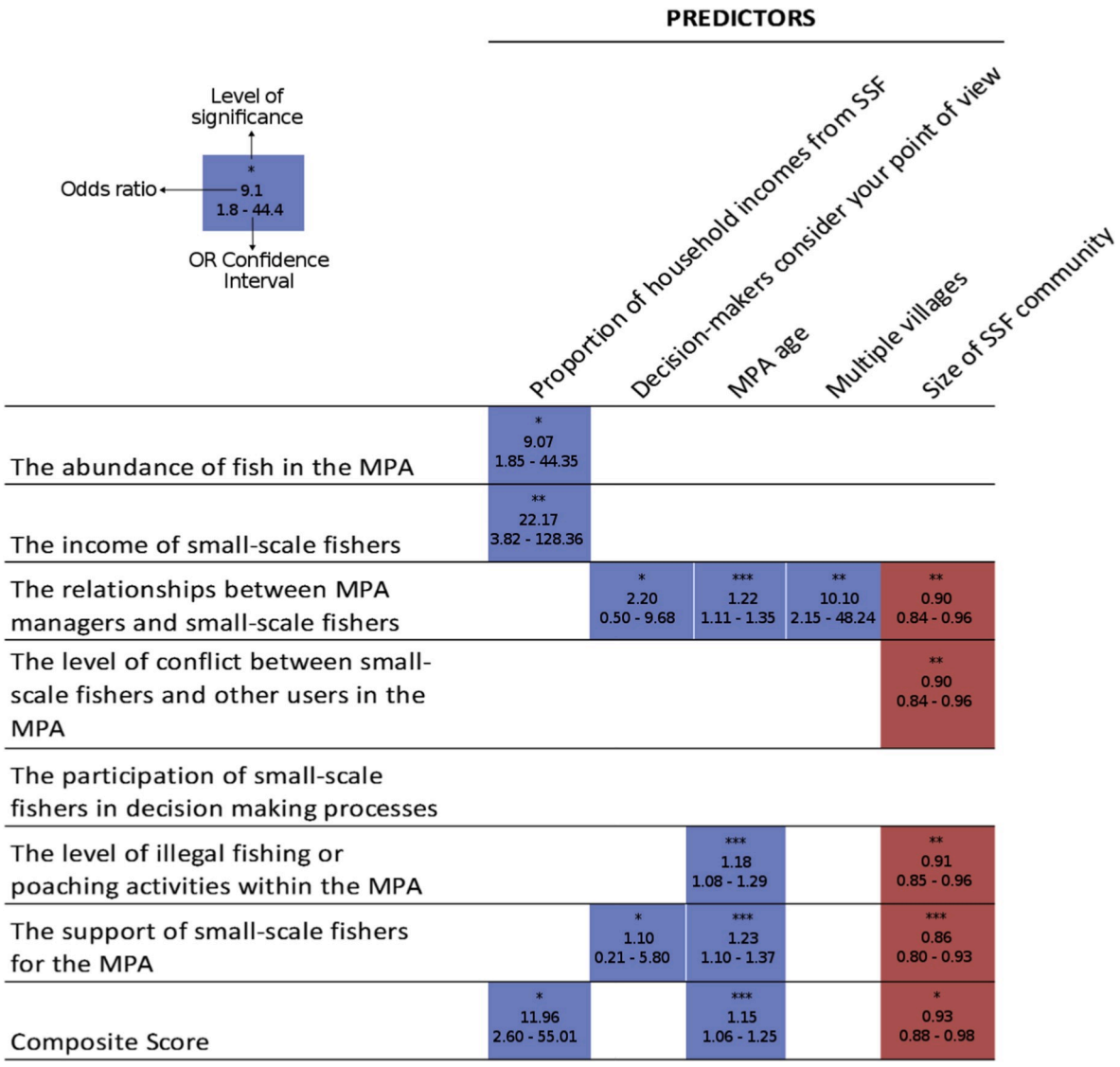

Fig. 6. Significant predictors, derived from proportional odds models, for the perceptions about the effects of the interventions implemented on the 9 variables considered. Perceptions on 'habitat' and 'catch' were not considered (and are not reported here) for collinearity issues (see Methods). Composite perception score capturing the overall effectiveness of the governance interventions implementation is the sum of the nine different items. Blue colour indicates positive relation with predictors, red colour indicates negative relation with predictors. For each significant predictor, odds ratio (OR) and the relative confidence interval (CI) are reported, together with the level of significance (see legend on top-left, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$). See Supplementary Table SM6 for the full summary of the models. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

significant changes in these factors. The social and governance factors that can be accrued are however much more immediate (Blount and Pitchon, 2007; Christie, 2004; Kelleher and Recchia, 1998; Mascia, 2004).

Our results highlighted that the perceived effects of tested interventions varied between MPAs and also when considering the different socio-ecological variables. This could be due to, among other things, the different contexts of each MPA (socioecological and in terms of MPA management and governance, Bennett et al., 2020) highlighted by the significant effect of some of the predictors we considered in our analyses. The fishers who reported no perceived benefits, could have done so due to the short time frame the governance interventions were implemented which was perhaps insufficient to modify their perceptions. Alternatively, these fishers could have already taken part in previous participatory processes that were unsuccessful, or have in some way been deceived by false promises regarding the MPAs management and potential results and are therefore more resigned to being cautious (Chaigneau and Brown, 2016; Hogg et al., 2019).

It is important to point out that perceived benefits related to ecological and economic factors do not necessarily mirror factual improvements in these variables. Yet, perceptions represent crucial information and despite often being dismissed as anecdotal, can be effectively used to improve management (Bennett, 2016). Different methods (e.g. ecological assessment using underwater visual census or similar techniques to investigate potential change in fish abundance) can provide complementary insights and enable accurate impact assessments of biological and economic change over a longer period.

Our results concur with previous research that reveal employment of good governance processes (e.g. involving stakeholders in decision-making) and management of social aspects are key for ensuring local support for conservation (Bennett et al., 2019). The demand of each MPA to create the LGG represented a first step towards improved engagement and is representative of the much-needed shift towards co-management (Hogg et al., 2013). Management arrangements developed by LGGs or similar platforms, in line with what has been observed in community-based management in other geographical contexts, can

better align with local social and ecological conditions, conferring social benefits, such as: increased collaboration and learning among partners; integration of scientific and local knowledge systems; community empowerment; improved social capital, in terms of social cohesion between stakeholders, a key element to increase a community's adaptive capacity and to reduce vulnerability to local threats and global pressures that may threaten local small-scale fisher communities livelihoods and wellbeing; and higher levels of compliance (Kittinger et al., 2013; Norström et al., 2020; Silva et al., 2019; Thiault et al., 2019).

The findings of this study are extremely relevant considering the shortfall in MPA capacities, both in terms of staff and funds, as declared by MPA managers in the 11 case study sites, and as reported previously in other cases (Gill et al., 2017; Scianna et al., 2018). These features are key drivers of MPA ecological effectiveness (Gill et al., 2017; Scianna et al., 2019) and therefore represent vital aspects for MPA governance and management. Particularly relevant is the fact that enforcement and stakeholder engagement, two elements largely acknowledged as key to enhance MPA effectiveness (Di Franco et al., 2016; Edgar et al., 2014; Gill et al., 2017), represent major capacity shortfalls for the investigated MPAs. From this standpoint, we have presented a number of interventions that have been perceived positively by both MPA managers and small-scale fishers to overcome these shortfalls which sound promising to improve current MPA status. Specifically, increased enforcement can help reduce poaching, which is now acknowledged as widespread in MPAs globally (Bergseth et al., 2018, 2017) and represents a major threat to small-scale fisher communities (Thiault et al., 2019).

We highlight that collaborative interventions like the ones tested in this study can rapidly enhance stakeholder perceptions of MPA socio-ecological effectiveness and increase support toward MPAs. This could potentially lead to enhanced stakeholders' compliance with rules, both for members of local communities and also for external members through increased patrolling and voluntary surveillance (Bergseth et al., 2018; Thiault et al., 2019). Increased compliance could in turn contribute towards ecological benefits, that need more time to arise, and potentially impact stakeholders' livelihoods and wellbeing (through increased catches), finally creating a positive feedback loop for stakeholder perceptions and support toward conservation initiatives i.e. a virtuous cycle (Fig. 7).

However this cycle can be stopped, and the associated benefits quickly eroded if good governance stops, shattering stakeholder trust, expectations and potentially inducing a decrease in MPA support and compliance with rules (Chaigneau and Brown, 2016). This could prompt a decrease in MPA socio-ecological effectiveness and induce a vicious cycle, potentially pushing the system into a socio-ecological trap, defined as a situation when feedback between social and ecological systems lead toward an undesirable state that may be difficult or impossible to reverse (Cinner, 2011; Kittinger et al., 2013). The potential shift between the virtuous and vicious cycle, with all the related societal implications, stresses further the importance of giving sufficient attention to the human dimension in MPAs and making use of information on both the factual and perceived socio-ecological effectiveness of the MPA. From this point of view, we also highlighted that the perceived effectiveness of conservation interventions can be affected by a set of elements at individual (e.g. demographic), community (e.g. size) and MPA (age, size) levels, that represent potential leverage points upon which to act in order to maximize perceived effectiveness and enhance support toward MPAs. Specifically, perceptions of socio-ecological effectiveness are positively associated with small communities, old MPAs and fishers with high proportions of household income derived from small-scale fisheries. It is interesting to note that our results suggest that the overall size of the fisher community is relevant in shaping perceived effectiveness of the interventions. This may suggest that MPA management and governance efforts, in terms of capacities and resources allocated, should be planned based on the size of the community, adding to recent findings suggesting that these elements should be set based on MPA surface area (Scianna et al., 2019). These two variables (size of the community and MPA surface area) are not necessarily related, and further investigations should be carried out to understand how and if they interact. It is also possible that in large communities economic activities are more complex and diversified, meaning they could be less dependent on the MPA conservation status.

To create the virtuous cycle and/or prevent it from stopping it is crucial for an MPA to: 1) set the right conditions to determine the onset of the reserve effect, in terms for instance of increased fish biomass, that will then potentially translate into socio-economic benefits for local communities; and 2) support participation and create allies of local communities in decision-making and management processes to help generate long-term support for conservation initiatives.

We acknowledge that the establishment of a LGG or similar collaborative platform alone is insufficient to ensure long-term change. In addition, we recommend, that future studies sample a broader group of stakeholders, and extend participation in decision-making beyond small-scale fishers to include a wider array of actors, especially as MPAs

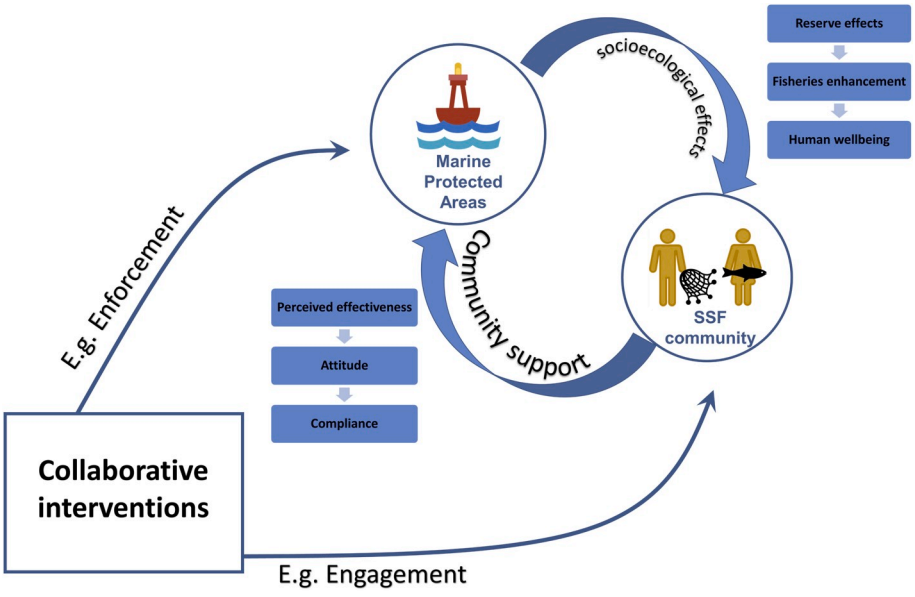

Fig. 7. Conceptual scheme of the cycle linking Marine Protected Areas (MPA) socio-ecological effectiveness and community support. Blue filled boxes with arrows indicate the potential chain of elements for each item represented in the two thick curved arrows (socioecological effects, community support). Collaborative interventions can affect both the MPA and its socioecological effectiveness (e.g. through enforcement and surveillance) and SSF community and its support toward the MPA (e.g. through engagement and participatory decision-making). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

are often multi-use or affect a wider range of actors, thus ensuring a more complete representation of community' needs.

This study has a number of relevant implications for other conservation initiatives, policy makers and practitioners. First and foremost, it reveals that conservation practitioners and managers need to be attentive to the quality of governance and the social impacts of conservation (Bennett and Satterfield, 2018; Borrini-Feyerabend and Hill, 2015; Lockwood, 2010). It confirms the merit of engaging stakeholders in long-term and well managed decision-making processes that ultimately affect their livelihoods (Jentoft, 2005; Wilson, 2003). In addition, this study highlights that the positive perceptions yielded were accrued by giving increased attention, effectiveness and continuity to governance and management processes (Bennett et al., 2019) and not reliant on improved ecological or fisheries outcomes (as there was not enough time to see these results). Second, it highlights the benefits of considering the human dimension and people's perceptions (Bennett, 2016; Voyer et al., 2012). Monitoring people's perceptions can help confirm whether and/or which management interventions can increase support for MPAs or other conservation initiatives (Bennett, 2016; Hogg et al., 2019, 2017b; Voyer et al., 2012). Finally, the testing of multiple interventions across different MPA contexts has provided actionable insight into the overall feasibility and effectiveness of each. Given the variability of MPAs included in our relatively large and heterogeneous sample, which represent a wide range of socio-ecological and governance contexts, the governance approach and governance interventions tested are transferable and can likely be adapted to many MPA settings globally.

Our recommendation for other MPAs aiming to increase the level of support is to permanently involve stakeholders in the process. Following a similar governance intervention approach to that outlined in this paper can have positive impacts on perceptions and level of support for MPAs, with relatively low demands in terms of time, money and resources from the MPA and stakeholders. For each of the 11 MPAs involved in this project our recommendation for the next step is to establish what kind of engagement the fishers want, and perhaps employ a system of trial and error experimenting with different engagement strategies until one that is suitable for all stakeholders is found while still ensuring effective and efficient decision-making (Hogg et al., 2017b). In addition, we strongly recommend that participatory decision-making processes employ neutral parties trained in facilitation, mediation and conflict resolution.

5. Conclusion

Engagement of local people and perceived MPA socio-ecological benefits are crucial elements for garnering support for and long-term success of conservation initiatives. Here we have reported an approach tested in 11 MPAs that provides clear and actionable elements that can help to support this process. This study demonstrated that small-scale fishers' perceptions of MPA ecological effectiveness, social impacts and good governance can be quickly enhanced through collaborative conservation interventions co-produced with local communities. Although perceptions towards ecological and economic outcomes were positive it was perceptions of governance and other social factors that were found to have the greatest prospect of being improved in the short-term by the management interventions tested and approach applied. If MPAs and stakeholders continue to apply these interventions, it is likely that there will also be positive impacts on ecological and economic factors. The results of this study strongly suggest that conservation practitioners need to be attentive to all three dimensions – ecological effectiveness, social impacts and good governance - during the implementation and ongoing management of conservation initiatives, yet small changes in the governance structure and increased engagement of fishers and other actors can easily and quickly improve overall support for conservation. It is essential to ensure good governance is sustained over time and adequately resourced (financially and by full-time trained personnel who can carry out participative decision-making processes).

Declaration of competing interest

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

CRediT authorship contribution statement

Antonio Di Franco: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft. **Katie E. Hogg:** Conceptualization, Methodology, Investigation, Writing - original draft. **Antonio Calò:** Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft. **Nathan J. Bennett:** Conceptualization, Methodology, Writing - original draft. **Marie-Aude Sévin-Allouet:** Investigation, Writing - review & editing. **Oscar Esparza Alaminos:** Investigation, Writing - review & editing. **Marianne Lang:** Investigation, Writing - review & editing. **Drosos Koutsoubas:** Investigation, Writing - review & editing. **Mosor Prvan:** Investigation, Writing - review & editing. **Luca Santarossa:** Conceptualization, Investigation, Writing - review & editing. **Federico Niccolini:** Conceptualization, Writing - review & editing. **Marco Milazzo:** Conceptualization, Investigation, Writing - review & editing. **Paolo Guidetti:** Conceptualization, Investigation, Writing - review & editing.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2020.110757.

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