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Social networks and information flow: Building the ground for collaborative marine conservation planning in Portofino marine protected area (MPA)

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1. Introduction

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

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http://dx.doi.org/10.1016/j.ocecoaman.2015.11.023 0964-5691/© 2015 Published by Elsevier Ltd. 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 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 decisionmaking 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

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2. Materials and methods

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

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).

resource management such as power relations, information

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 comanagement 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.

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 374 ha). 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.

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 to characterize the strength of their relationship (strong, weak or no tie) with each member in the stakeholder list. In order to measure the perceptions on the strength of ties that stakeholders maintain with each other, no previous definition regarding the links' strength was stated. To define the boundaries for stakeholder involvement, participants

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

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 56×56 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 ICTs 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

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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_{ii} $(i \neq j)$ 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 coreperiphery 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 from all other actors. 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).

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

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

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

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'). 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

Table 2			
Top 10 actors in centrality te	rms, norma	lized 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.

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.

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 their 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 and access 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.

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, CON-ISMA, 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.

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



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

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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.

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).

Table 2

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



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.

the bisector line (dashed).

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.

Yen and Leskovec (2014) noticed that web networks exhibit a single dominant core that administers information around a

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

common interest or topic, similar to the core-periphery structure in a social network. In Portofino MPA, relevant core actors such as UNIGE,¹ REGLIG² and MINAMB³ 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 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 the provision of open access data. Scientists should be committed to making their data available and assure they communicate with 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 comanagement. For instance, the European Commission has adopted web platforms, such as the portal 'Your voice in Europe'⁴ for open consultations and discussions with stakeholders regarding policy-related issues. SeaSketch⁵ 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 features

- ² www.cartografia.regione.liguria.it; www.regione.liguria.it/servizi-on-line/ tipologia/cartografia.html.
- ³ www.pcn.minambiente.it/GN.

⁵ www.seasketch.org.

¹ Marine Coastal Information System, MACISTE: www.remare.org/cartografiaamp-maciste.

⁴ http://ec.europa.eu/yourvoice.

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adopted from 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 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 coreperiphery 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 decisionmaking, 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.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http:// dx.doi.org/10.1016/j.ocecoaman.2015.11.023.

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