Stakeholder participation and the use of web technology for MPA management

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Stakeholder participation has received an increased attention as a key process for enhancing open and transparent decision-making in Marine Protected Areas (MPAs) and mitigating conflicts between different interests for the same resources. A wide range of advanced web tools is available nowadays that integrate stakeholder participation by generating new information and allow interaction between actors in MPA management. However, such technologies are frequently used without much consideration of the heterogeneity of stakeholders, the complexity of the decision to be made how particular stakeholder groups understand and are able to relate to these technologies.

In order to understand how technology corresponds to the changing needs towards community-based management MPA, we reviewed a range of different participation strategies through examples of web tools from the worldwide arena, starting from simple towards more sophisticated platforms that have been developed in order to better inform decision making, and contribute in a more effective and efficient MPA management. Finally, we suggest a theoretical framework for the development of a community-based web tool with the capacity to incorporate the philosophy of stakeholder participation by generating new and high quality information for a transparent MPA management.

Keywords: Stakeholder participation; Marine Protected Area; resource management; Decision Support Systems; web tools

1. Stakeholder Participation in Marine Protected Areas: a challenge for managers

Establishing Marine Protected Areas (MPAs) is one mechanism amongst others that addresses challenges regarding the effective protection and maintenance of ecosystem

health, the local socio-economic development and the mitigation of conflicting coastal uses (Beck et al., 2009; Ehler and Douvere, 2009; Gopnik, 2008; Halpern et al., 2012; Olsson et al., 2008). Conflicts in MPA management are often hindered by differing interests in the same resources within a fixed space [3,4] De Freitas et al., 2011; Olsen et al., 2013]. Coastal and marine resource managers must bring together stakeholders, and involve them in the management process through multi-disciplinary participatory approaches in order to reach mutual understanding and shared decisions [8-10]; Tempesta & Otero, 2013; Pomeroy et al., 2004). Stakeholder participation has been characterised as a long and time consuming practice that often slows down decisions [18] and increases the risk of MPA management failure due to distortion of public opinion and strong economic interests [21]. However, many studies argue that local communities are more likely to commit to and comply with long-term conservation strategies when they are involved in MPA decision making processes [23]; [31-36]). The importance of stakeholder involvement has been highlighted in a several international initiatives, such as the Aarhus Convention, the Earth Summit and the European Water Framework Directive.

Stakeholder participation (Table 1) ranges from application of more “extractive” approaches where power is retained in the hands of the administrator and information is limited to passive provision towards stakeholders [11-13], to more interactive or “empowering” approaches like negotiation and consultation where power and responsibility are equally shared to stakeholders [14,15].

[Table 1 here]

The selection of effective communication and information strategies to target the relevant audiences is vital [40,15,29]. A spectrum of flexible participatory techniques

may be necessary to be implemented depending on the objectives set, the level of involvement desired, the target groups, their characteristics and preferences, the past events that have formed the social network, the time constraints and finally the facilitators' experience (Luyet et al., 2012).

Effective participatory process in order to dynamically involve stakeholder groups such as scientists, resource managers, agency staff, stakeholder advisory groups, NGOs, policy advisors and private sector and build constituency for increasing the quality of the MPA decision making process, should support:

- (1) Fair and transparent decision-making, where all the diverse stakeholder groups are given the opportunity to participate and share viewpoints (Smith Korfmacher, 2001; Duram and Brown, 1999; Reed, 2008; Webler et al., 2001; Moote et al., 1997; Luyet et al., 2012). This also suggests different dissemination and outreach of information in diverse types in order to reach all preferences and understanding (Masalu, 2008; Dalton, 2005; Creighton, 2005; NOAA, 2007).
- (2) Decisions based on complete information, where integration of local and scientific knowledge ensures deep understanding of all critical issues and stakeholder concerns are brought to light and are addressed throughout the process (Luyet et al., 2012). Informing the public includes all kind of activities that promote data availability, accessibility, insurance of data quality and consistency (Carballo- Cardenas et al., 2013), but also collection and validation of information through stakeholders. This also implies that complicated issues should be presented in a way that allows stakeholders from diverse backgrounds to increase their understanding on these issues [6].

- (3) Active participant involvement and positive participant interaction, where users are linked to each other and share information more intensely (De Longueville, 2012). Stakeholders not only receive information but also actively contribute in the two-way information input (data, local knowledge, experience and perceptions), or to the development, evaluation and implementation of management plans through knowledge sharing, consultation and dialogue [16,17]; Dalton, 2005; Creighton, 2005; NOAA, 2007). Positive interaction between stakeholders suggests that actors cooperate with each other, possible conflicts that are raised are transformed into positive and common understanding of the issue and viewpoints of different stakes through group problem-solving (Dalton, 2005; Creighton, 2005; NOAA, 2007) generating new options regarding the use of resources [9,24].
- (4) Capacity development, in the form of environmental education, awareness and social communication are needed to guarantee behaviour and attitude changes so that the management processes can be sustainable over time [15,100] [77][79,80] [78]. Social change takes place as people learn from each other through their social networks (Prell et al., 2008).
- (5) Efficiency and effectiveness, that will guarantee that the process is successful and sustainable in financial and time limitations (Leach and Pelkey, 2001; Kenney et al., 2000; Luyet et al., 2012).

Web technology with the delivery of spatial information and the use of effective tools in participatory spatial planning has made an important effort in maximising the effectiveness of stakeholder participation in decision-making (De Freitas et al., 2011) through the integration and transformation of local knowledge into maps that are

easier to understand by all different audiences [65,66]. Ecosystem-based approaches like Integrated Coastal Zone Management (ICZM) and Marine Spatial Planning (MSP) have intensively used technology to inform the spatial distribution of the full array of interactions among ecosystem components and human activities (Foley et al., 2010; Katsanevakis et al., 2011] and have brought together multiple stakeholders in order to balance the intensity of existing and potential activities (8-10). Nevertheless, such technologies and related spatial information are frequently used without much consideration of the heterogeneity of stakeholders, the complexity of the decision to be made how particular stakeholder groups understand and are able to relate to these technologies (De Freitas et al., 2011; Luyet et al., 2012). Given the multiple challenges faced in MPA management today [38,39], the current global momentum in establishing MPAs and MPA networks (UNEP-WCMC, 2008; Wood et al., 2008), and the calls for development of user oriented Informational Systems on protected areas (Bertzky and Stoll-Kleemann, 2009; Corrigan and Kershaw, 2008; Carballo-Cárdenas - 2013), there is an increasing interest for the capacity of web technology in order to enhance interactions between and within user groups, accelerate information exchange and improve the performance of resource management (i.e. Garcia et al. [42]; De Longueville, 2010; Lin et al., 2013, Yang et al., 2010).

In order to understand how technology corresponds to the changing needs towards community-based management MPA, we reviewed a range of different participation strategies through examples of web tools from the worldwide arena, starting from simple towards more sophisticated platforms that have been developed in order to better inform decision making, and contribute in a more effective and efficient MPA management. Finally, we suggest a theoretical framework for the development of a community- based web tool with the capacity to incorporate the philosophy of

stakeholder participation by generating new and high quality information for a transparent MPA decision making process.

2. Web technology serving stakeholder participation in MPA management

2.1 Social media

Social media (or “Social Web”) have become extremely popular [56] by offering attractive means for interaction and communication [57]. The power of Social Media lies on the ease and speed with which data can be gathered and distributed by a large number of individuals using open software [58]. Numerous social media sites, like Facebook and Twitter, provide a large quantity of information and complexity, easily shared between users and groups through a well-linked network of users [51,59,60][56]. For example functions like social bookmarking allow users to save different forms of information (URLs from Web pages, blog articles, images or videos), share them with other users, provide comments and link them with keywords or other web entities by means of “tagging”, or comment on the quality of information provided by “rating” and “liking”. These types of multi-sourcing provide access to a huge quantity of resources available through the internet that are indexed, classified and commented upon collectively [53] and increases the possible channels and the speed of two-way information flow within the net. Applications that engage audiences such as real time communication and instant messaging forums, discussion boards and groups, wikis, emails and all other emerging electronic/digital communication applications have the effect of boosting the capacity of these tools to provide successful outcomes through consultation and dialogue processes [51].

3.1.1. Examples of Social media in marine resource management

Even though the capacity of Social media tools such as Wikipedia, Facebook, Twitter for biological and ecological applications is still relatively underexplored within scientific literature [58], Social media are commonly used in resource management to survey diffusion and delivery of news to the public in a multimedia online format [Sayce et al., 2012] and reach an even broader audience and attract attention to a survey or a website. For example, in the case of California Marine Life Protection Act that aimed at the creation of an MPA network, blogs through Facebook and Twitter were extensively used to address the public perception challenges faced by the Initiative and inform the development of public outreach messaging and materials (Sayce et al, 2013). Open source social media may also facilitate the collection of additional information through targeted surveys or enhance consultation, as in the case of the Social web site established by the European Commission “Your voice in Europe” (<http://ec.europa.eu/yourvoice>) which is a “single access point” of communication with the stakeholders may express their opinion on EU policies and influence their direction. Communication is based on consultations through straightforward online questionnaires, making it easier both for respondents to participate and for policy makers to analyse the results, and on discussions on the main policy issues and chat on-line to EU’s leaders through their personal Facebook and Twitter accounts. The website has been set up in the context of the Interactive Policy Making (IPM) initiative that asks the use of modern technologies, particularly the Internet, to allow both Member State administrations and EU institutions to understand the needs of citizens and enterprises better. Your Voice in Europe enables stakeholders to play an active role in the European policy-making process and is anticipated to assist policy development by allowing more rapid and targeted

responses to emerging issues and problems, improving the assessment of the impact of policies (or the absence of them) and providing greater accountability to citizens. Launched in 2001, IPM has allowed the successful launch of more than 370 public consultations available on the web portal Your voice in Europe (EC, 2012).

3.2 Citizen Science platforms in marine resource management

A key aspect in collaborative geographic applications is the interoperability between geospatial data and tools available on the Internet (i.e. WebGIS) for users to build up their content [54]. Online web mapping services are essential for visualising and inspecting the geospatial data across a map, without the need for specialised technical skills (McClintock, 2013). A variety of free and open source Application Programming Interfaces (APIs) and APPs (applications designed to run on smart phones and tablets) have increased the capacity for freedom of geographic data and support for individual planning using low cost technology [55]. These advantages have made such applications popular for creating coordinated networks of volunteers [69] who undertake research- related tasks such as observation, measurement, or computation [70]. This form of research collaboration or collection and outsourcing of information by non-experts is known as “Citizen science” or “community-based monitoring” [71,72,58]. Citizen science addresses the goals of Agenda 21 and the Rio Declaration on Environment and Development (UN 1993), by supporting the notion of community capacity building and involvement in Marine Protected Area (MPA) management globally and by bringing together the public and multi-sector agencies to address natural resource management issues [73],[76] (Irwin et al. 1994; Koss et al., 2009).

3.2.1 Examples of Citizen Science platforms in marine resource management

ReefCheck is one of the most successful examples of community-based monitoring worldwide, based on recreational divers that have surveyed over 300 reefs in 31 countries [78]. The worldwide Reef Check Foundation (www.reefcheck.org) is an NGO dedicated to the protection of coral reefs in several places in the world and is supported by national agencies in several countries. Monitoring activities involve volunteers such as recreational divers, students, and citizens. Volunteers are adequately trained to observe, identify and verify the status of coral reefs. Today this initiative is followed in several areas worldwide (i.e. Italy www.reefcheckitalia.it, Philippines www.reefcheckphilippines.org, Malaysia www.reefcheck.org.my) aiming to stimulate local action towards tropical and temperate reef protection. In 2005 Reef Check California developed a specific volunteer monitoring program for California's rocky reefs.

Reef Check Italia Onlus (www.reefcheckitalia.it), established in 2008, has developed a protocol for the monitoring of Mediterranean temperate reefs, the data collected by volunteers being stored in an online database (www.progettomac.it). ReefCheck Italia Onlus has contributed significantly in the organisation and development of protocols for the Coastal Environmental Monitoring (CEM) along Italian coasts, focusing its activity in Marine Protected Areas, mainly promoting the active participation of both recreational divers and students, who have the task to collect data underwater (Coastal Submerged Environment Monitoring, CSEM) and on the shoreline (Coastal Emerged Environment Monitoring, CEEM) respectively [84]. The database assembles information on selected endangered, invasive and keystone species and marine

litter (on the beach and on sea bottom). To ensure data quality, a password is needed to upload information, which ensures that only trained volunteers contribute information. Quality control includes both automated processes and manual validation. ReefCheck Italia Onlus provided useful monitoring information on coastal biodiversity of Tavolara Punta Coda Cavallo MPA regarding the geographic, depth and abundance distribution of 14 species selected for the CSEM protocol for the Tyrrhenian Sea, and temperature profile data (recorded through dive computers and data logger devices) on a seasonal basis. Apart from the contribution to the monitoring of the MPA, ReefCheck Italia Onlus, boosted the knowledge and the direct perception on the effects of human activities and increased the awareness of local stakeholder groups, such as divers [84]. Currently ReefCheck is developing an app for smartphones in order to facilitate monitoring activities.

3.3 Multidisciplinary cartographic platforms

Recent studies have argued that advanced participatory platforms are the new generation of highly sophisticated tools that combine geospatial technology and Web 2.0 to reach a broad range of stakeholders with varied technical ability (or no technical expertise), so that they contribute their knowledge in an efficient and transparent way [55] (Ciobanu, Roche, Badard, & Caron, 2007; Goodchild, 2007).

This advanced technology actually comprises cloud-based collaborative content systems for the mapping, processing and analysis of geospatial information.

Therefore, these tools offer a lot more than just online visualizations of geographic information (Gould, 2008). Community-based portals may help people understand the

real-world implications of different management regimes and environmental conditions and reveal trade-offs among possible management scenarios (Beck et al., 2009). Interactive web portals require simply an internet connection and a web browser in order to view and query geographic data using interactive maps and a toolbox for basic mapping functions (viewing, navigating, zooming and panning). Some of these tools provide personal space to administrators, or users, that enables data owners to upload and visualise their data, interact with the data and maps, or integrate multiple data layers to inform their designs. Additionally, data can be private or shared with other stakeholder groups, stimulating comments and/or consultation through forums. For most of these tools no prior technical expertise is required. Considering the complexity of the tools examined, most of them can incorporate powerful data analysis.

3.3.1 Examples of advanced participatory platforms for resource management

The common database on Mediterranean MPAs (MAPAMED, www.mapamed.org) developed by MedPAN and RAC/SPA aims to collect, organise and provide efficient, open accessed geospatial information and public documents. The inventory was first established in 2008, but was completely upgraded in 2012. Currently it provides information regarding geo-location for 677 MPAs covering about 7% of the total number of MPAs worldwide [87], habitats and species existing under special protection status, and their management and legislature documents. MAPAMED allows users to visualise the Mediterranean MPAs through a map interface and access referenced information, or search data through an advanced search. Information provided is based on the UNEP-WCMC (2010) data standards in order to facilitate sharing the protected areas data on an international scale. More detailed information

was collected from MPA managers through online surveys, which may update directly information on their MPA, or validate existing information (Gabri et al., 2012). The database has enabled the analysis and assessment of the status and trends of the Mediterranean network of MPAs according to international targets over the long term (Gabri et al., 2012). MAPAMED database anticipates to become the region's baseline and to supply international databases (Gabri et al., 2012). Nevertheless, due to the portal's objective, MAPAMED provides limited interaction with the user.

Additionally, the World Database on Protected Areas (WDPA, www.wdpa.org) is a comprehensive global inventory of the world's protected areas created through a joint project of UNEP-WCMC and the IUCN World Commission on Protected Areas. A broad range of open accessed data is held within the WDPA for each site including information about designation and IUCN management category, historic changes in areas' boundaries, the annotation of habitat fields and administration. Critical information sources have been strengthened by the establishment of a consortium of international conservation organizations in 2002, which support the pooling of information from a broad range of resources and collaboration on the improvement of the structure of the WDPA, as well as the quality and quantity of the core data contained (Chape et al., 2005). The WDPA provides a unique tool to investigate progress in the development of the global network of protected areas, provides summary information at global, regional and national levels, while the GIS makes it possible to undertake spatial assessments, combining the protected areas information with other data layers, such as species or habitats and summarize the 'effectiveness' of the protected areas network. Since 2002, protected areas information from the WDPA has provided regular statistical and analytical information for the preparation

of technical reports to the CBD Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) (Mulongoy & Chape 2004), thereby contributing to the key decisions on protected areas. Information provided by the portal is regularly updated (every 3-5 years) (Chape et al., 2005).

One of the most well-known examples that boosted the capacity of web platforms and cartographic design serving Marine Spatial Planning using the power of the web and GIS, is MarineMap. MarineMap (www.marinemap.org) responded to the call of California's Marine Life Protection Act Initiative (MLPAI) for active public involvement in the planning processes of Marine Protected Areas in California [88; Fox et al., 2013]. MarineMap Oregon (www.oregon.marinemap.org) is a “mature” dynamic web portal and thus it provides a well-structured and informed Decision Support Tool for marine, terrestrial and atmospheric environments that has been used to inform decision-making (Beck et al, 2009; Merrifield et al., 2012). Map layers can be viewed and queried in reference to the three-dimensional Google Earth API which is a familiar, user-friendly and open source interface that provides cross-platform functionality. However, Google Earth API requires the download and installation of the Google Earth Plugin, which in many situations is not allowed to users.

Information and metadata are well organised and linked to each other and therefore easily located by users with no technical expertise [55]. MarineMap was configured to support iterative sketching (“geodesign”) of different individual perspectives to map layers and inform marine spatial planning, and supported statistical analysis of data. It is adapted to be implemented on a global scale. MarineMap has evolved three times based on users' need to reach wide acceptance from the public and its total cost ranges from \$250.000 to \$700.000 per region [55].

SeaSketch (www.seasketch.org) is a next generation decision support tool for collaborative ocean planning for effective ocean planning for a range of end users, including government, industries, and regional institutions. SeaSketch was developed by the McClintock lab of the University of California, Santa Barbara (UCSB), Center for Marine Assessment and Planning to deliver a cutting-edge decision support tool and was released in November of 2012. SeaSketch in reality is a web-based ocean geodesign platform accessible via ArcGIS Online where users are able to initiate their own project by uploading map layers and defining "sketch classes". What is unique about SeaSketch is that the author can sketch on the different layers and share them with others to trigger discussions through an online map-based chat forum [89].

Regardless of technical or scientific ability, users of SeaSketch are able to easily view map data from authoritative sources from all over the world (e.g., distributions of human activities and resources). Using these maps as a reference, users are then able to sketch, save, and share management plans and discuss them with other users via a facilitated chat forum tied directly to their maps. SeaSketch is always adding to its current suite of spatial analytics, which in the future will include spatial dimensions of trade-offs in which users submit the spatial features of their plans to a biological-economic model of trade-offs between ecosystem services in relation to potential management strategies (Wright, 2013). Unlike MarineMap, SeaSketch has an elaborate, interactive help system that allows users to ask questions, submit comments and vote for feature enhancements. SeaSketch has built in tools for designing and conducting surveys to gather new information about the distribution of resources and human activities in and around the ocean. Therefore, this data gathering capability SeaSketch provides is unique and worth mentioning feature. Consultation process along with sketches and comments can be extracted or included in a report. End-users

may use easily the tool as a result of a fair amount of user testing with no or low experience in WebGIS. However, advanced analysis for environmental and socio-economic assessments or future scenarios is possible but demands high-level programming expertise. Although SeaSketch was very recently established, it is a mature tool with demonstrated capabilities. It is a straightforward and user-friendly tool that supports interactive consultation and dialogue between stakeholders through an innovating approach.

In 2013 the Barbuda Council used SeaSketch to visualize and analyze geospatial information about the distribution of resources and human activities in Barbuda. The Council members using simple drawing tools authored draft maps indicating areas where any type of fishing is completely prohibited. Sketches were immediately evaluated to determine whether they met science and policy guidelines for ecosystem protection and minimizing impacts to fishermen on the island. The final outcome is a proposal of six sanctuaries in Barbuda. A public discussion forum in SeaSketch was used solicit feedback from the local stakeholders of Barbuda who had the opportunity to consult and use sketching tools to author modified versions of the council proposal and evaluate them using the reporting and analytical features in SeaSketch (SeaSketch News, 2013). Currently it is being applied also in the UK, US, Canada, New Zealand, the Mediterranean, the Galapagos, and Australia. SeaSketch has relatively low maintenance costs. The annual cost of SeaSketch is \$10,100 per year for the license and support fee. If hosting map services is required, the average cost is \$5,000 per year. Additionally the maintenance cost is \$15,000 / year (Will McClintock, pers. commun.).

4. Discussion

Technological advances are increasing rapidly seeking to provide solutions to the changing demands of users (91) and may provide a vehicle for reaching out to communities and institutions that hold crucial information capable of informing decisions and drawing new stakeholders into the MPA planning process [90].

However, successful attempts to include the public in a more communicative, interactive and organised way in MPA management worldwide are still limited [54].

A successful participative tool corresponding to the high rate of needs and technological development should provide efficient information, comprehensively visualised by a range of stakeholders that are involved into a collaborative process through an interactive channel (Lu, 2011; Lin et al., 2013a). A generalised framework for the development of a successful community web-based tools is shown in Figure 1.

In any participatory approach (Figure 1) the initial step is to define clearly the aims and the objectives to reach through the participatory process. Stakeholders through participation may contribute in the planning process by setting of priorities, objectives, purpose of spatial management plans, or even help to identify, group, and rank management problems, needs, and opportunities (Pomeroy & Douvere, 2008). During the evaluation phase stakeholders may be involved in selecting of plan options (Pomeroy & Douvere, 2008). Even after the implementation of management plans, adaptive management requires consultation about the overall effectiveness in achieving goals and objectives and exploration of alternative plans (McClintock, 2013). Identification, characterisation and prioritisation of the stakeholders is necessary in order to recognize the key actors who have a vested interest in the focus area, the ones who are weaker and need to be heard, or may already have a voice in

determining and assessing management strategies, and the ones who may participate in the process in a future step (Grimble and Wellard, 1997; Mushove and Vogel, 2005- Prell 2009).

Any participation strategy should aim for maximum participation through a broad community of practice to involve all relevant stakeholders early and continually in all phases of the planning, plan evaluation, implementation and post-implementation management phases, and not just consulted afterwards (Shepherd, 2004; Gleason et al, 2010; McCall & Dunn, 2012). Early and consistent engagement of stakeholders will help to break down conflicts, facilitate trust and information-sharing, and allow for a broad understanding and vision of the region being managed (Reed, 2008). However in practice not all people and/or organizations that have a stake in how the ecosystem is being managed is necessary to be actively involved in every stage of the decision making process, but in some cases they may simply be informed (Agardy et al., 2011- UNEP).

Web-based tools for communication are increasing in popularity since they are addressed to reach a much wider audience and support the collection of new information (McClintock, 2013) and support open software tools available to public. Providing accurate and efficient information on the distribution of resources and human activities in the MPA area, for the development and evaluation of spatial management strategy is the building block of an inclusive and transparent planning process [\[92\]](#) (McClintock, 2013).

Social media have been used effectively to generate the gathering of new information regarding MPA management through targeted interviews and surveys reaching a wide audience (Wright, 2013). A powerful characteristic however of the social web is its

capacity to reach a broader target audience and to distribute information in various forms corresponding to the preferences of each target group rapidly through news feeds and notifications and mobile technology (Kopke et al. [75]). Moreover, if we consider that actors are the nodes in social networks who are tied to one another through socially meaningful relations and share information (De Longueville, 2010; Prell et al., 2008), tools like Social media may provide useful information regarding stakeholders networks and their features, in order to identify key stakeholders, their roles and power, or measure components such as “homophily” and “centrality” for further analysis (e.g. Social Network Analysis; Prell et al., 2008). Several authors have highlighted the future potential of Social media in resource management as systems for collecting huge amount of information that is indexed, classified and commented upon collectively through “liking” buttons, shared bookmarks, pop-up windows and comment features associated with specific layers, maps or thematic content for immediate feedback (Kopke et al. [75]). Collaborative “tagging” or “rating” could potentially provide an estimate of the information quality (De Longueville, 2010). However these approaches have not been applied yet, and need to be monitored carefully in order to provide reliable information in the development of the participation process [75].

Other examples of web tools that have been used to support the collection of new information for MPA management needs are crowdsourcing and citizen science (Wright, 2013). Many governments and non-government agencies (NGOs) create monitoring programs based on citizen science in provide useful information and help the MPA reach its management objectives in times of resource and budgetary constraints [74,75]. Even though crowdsourcing datasets raise a series of questions in relation to their quality due to the non-expertise of volunteers [69, 81-83], it has been

proved that when appropriate training, standardised protocols and forms are provided information could be scientifically sound [78,84]. Collective intelligence offers a good alternative for retrieval, ordering and quality control for pertinent information, particularly for a huge and constantly growing mass of user-generated information (De Longueville, 2010). From this perspective, tools like these advance in time, cost and data accuracy since their capacity allows the simultaneous collection of multiple measurements on a single click (i.e. obtaining coordinates, pictures, measures, storage and organization of information collected). Therefore, citizen science may provide an excellent support for long-term monitoring of key species in MPA management, environmental awareness and involvement of public in general.

Interactive geospatial portals have an added-value as they integrate geographical dimensions and ecological and socio-economic information holistically (De Longueville, 2010) and have integrated high level of interaction required to efficiently support collaborative and participative processes in MPA management (Jankowski and Nyerges, 2001). Interactive community based web tools have helped MPA managers to engage stakeholders into a multi-disciplinary way, perform future scenarios and find optimal answers together through collaborative modes, such as by joining a virtual group through the Internet (Hara et al., 2003; Beck et al., 2009). These highly sophisticated web tools have used an intuitive user experience to simplify complicated spatial concepts and deliver openly critical information immediately through sufficiently interactive and attractive interfaces. Additionally, collaborative geodesign is the most reasonable solution to support information collection, collaborative experimentation, and decision-making, particularly when non-expert participants are involved in MPA management (Jankowski and Nyerges, 2001; Balram and Dragicevic, 2006; Elwood, 2006; McHugh et al., 2009)- Lin et al.,

2013b), and therefore reliance on GIS technicians (McClintock, 2013).

Different types of information need to be translated so it can be easily understood by people [99]. Visualization of information through maps is one of the basic advantages of geographic information tools (Longley et al., 2011). According to Churchill et al. (2001) and Abel et al. (2005), optimised visualisation of information is the best method for knowledge sharing and development of mutual understanding on the ecosystem processes between stakeholders with different backgrounds (Lin et al., 2013). Currently, traditional spatial analysis and visualization in 2D cannot meet the advanced needs of MPA management, particularly when solving problems related to complex spaces (Lin et al., 2013b). Providing multi-dimensional visualisation enables the presentation of geographic scenarios and phenomena to be more dynamic may create stakeholders a better understanding in complicated spatial issues [6] and thus, would enable them to consult or examine alternatives simultaneously by using common information spaces (Lin et al., 2013).

Discussions regarding the future web in a data-based form where any piece of knowledge will have a computer-understandable structure and content, so that the retrieval, discovery and combination of information will be a lot easier and more powerful for the end user are increasing (Berners-Lee and Fischetti , 1999, [95,59]). Utilizing the Semantic Web to support building knowledge and semantics into the next generation of scientific tools will support smart processing of geospatial metadata, data, information, knowledge, and services for virtual communities and multiple scientific domains (Hendler, 2003). The geospatial Semantic Web is a Web in which the browser, crawler, and other tools understand spatial content and can exploit this knowledge on-the-fly (Maué & Schade, 2009). Enabling technologies that

provide technological support functions, such as collecting data through observations and utilizing knowledge through a semantic web (Yang et al., 2010) are essential ingredient to cross-domain collaborations, interdisciplinary discoveries (Berners-Lee, Hendler, & Lassila, 2001; Brodaric et al., 2009).

Technology may provide a vehicle for reaching out communities and institutions that hold crucial information capable of informing decisions and drawing new stakeholders into the MPA planning process [90]. Tools we have in our hands today provide adequate technical solutions through the support and cooperation between the involved parties and the resulting input of knowledge (Luyet et al., 2012). However, it must be stressed that simply copying the best examples of participation will not guarantee success in other case studies (Luyet et al., 2012). Nor that a successful stakeholder participation guarantees that the process will reach successfully its targets (Luyet et al., 2012). Stakeholder participation alone is not enough. Social change occurs as people learn from each other through their social networks (Prell et al., 2008), but also through approaches like environmental education and capacity development are needed to guarantee behaviour and attitude changes so that the management processes can be sustainable over time [15,100]. Face to personal communication and face-to-face informal conversations for true dialogue and negotiaton is still crucial in real world cases of governance and decision making (Markantonatou et al., 2013).

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Table 1: Different levels of public participation (adapted from Bouamrame, 2006), their respected objectives (adapted from Douvere & Pomeroy, 2008), benefits of each approach (adapted by Bouwen & Taillieu, 2005) and traditional approaches (adapted from Areizaga et al., 2012) that have been commonly used in resource management.

Level of Participation	Definition	Objective	Advantage from Participation Process	Traditional tools (formal & informal)
Communication	Authorities responsible for MSP want to convey a message to a target audience and obtain approval for what their message asserts, suggests, and decides. Communication does not involve the stakeholders in any active way	Descending univocal flows	Information exchange provides the cognitive basis for enhancing the interchange between expert and experiential knowledge.	Official bulletins, publications, mailing, expositions, information numbers, web pages, announcements, personal meetings, phone calls
Information	Authorities responsible for MSP want to keep a target audience informed about their intentions, decisions and attempts to provide a basis of understanding; but don't expect any particular reaction. Unlike communication, the information is intended to be objective and represents a method of empowering stakeholders to react to decisions or take a position with full knowledge of the facts	Descending univocal flows		
Consultation	Authorities responsible for MSP collect the opinions of stakeholders you have consulted with no guarantee that the opinions expressed will be taken into account	Reciprocal flows	Provides the opportunity for organisational members to use valued skills and abilities towards important goals, to gain self-confidence and to engage in co-ownership of projects. It is the result of synthesis of information gained through participatory process.	Commissions, multilateral meetings, frameworks for agreement, phone calls, meetings
Dialogue	A form of 'horizontal' interaction among stakeholders who are positioned as equals. There is no precise purpose other than to know and understand one another better. Dialogue is intended to create a sense of proximity and mutual understanding about the problems and solutions for a particular MSP area	Develop proximity		

Concertration	A form of 'horizontal' interaction among stakeholders who are positioned as equals. Unlike dialogue, the purpose is to develop a common position among a group of stakeholders that can be presented or defended before the authorities responsible for MSP.	Determine objectives and actions	Bringing together stakeholders of diverse backgrounds (marine policy, NGOs, private sector, conservation, marine recreation) to achieve representation on a specific issue to identify MPA objectives and process a set of management strategies.	Elections, thematic tables, forums, surveys, interviews, commissions, working groups, manifestations
Negotiation	A form of 'horizontal' interaction in which both stakeholders and the authorities responsible for MSP have equal powers for decision-making	Reach a decision		

Figure 2: Generalised framework for developing a community web tool for enhancing participation and empowerment in MPA management.

Technological aspect

Stakeholder aspect

1. Identify stakeholders, characteristics, preferences
2. Identify participation level and time
3. Select Participation tools and methods