ENHANCING STEWARDSHIP IN LATIN AMERICA AND CARIBBEAN SMALL-SCALE FISHERIES

MARITIME STUDIES THEMATIC SERIES

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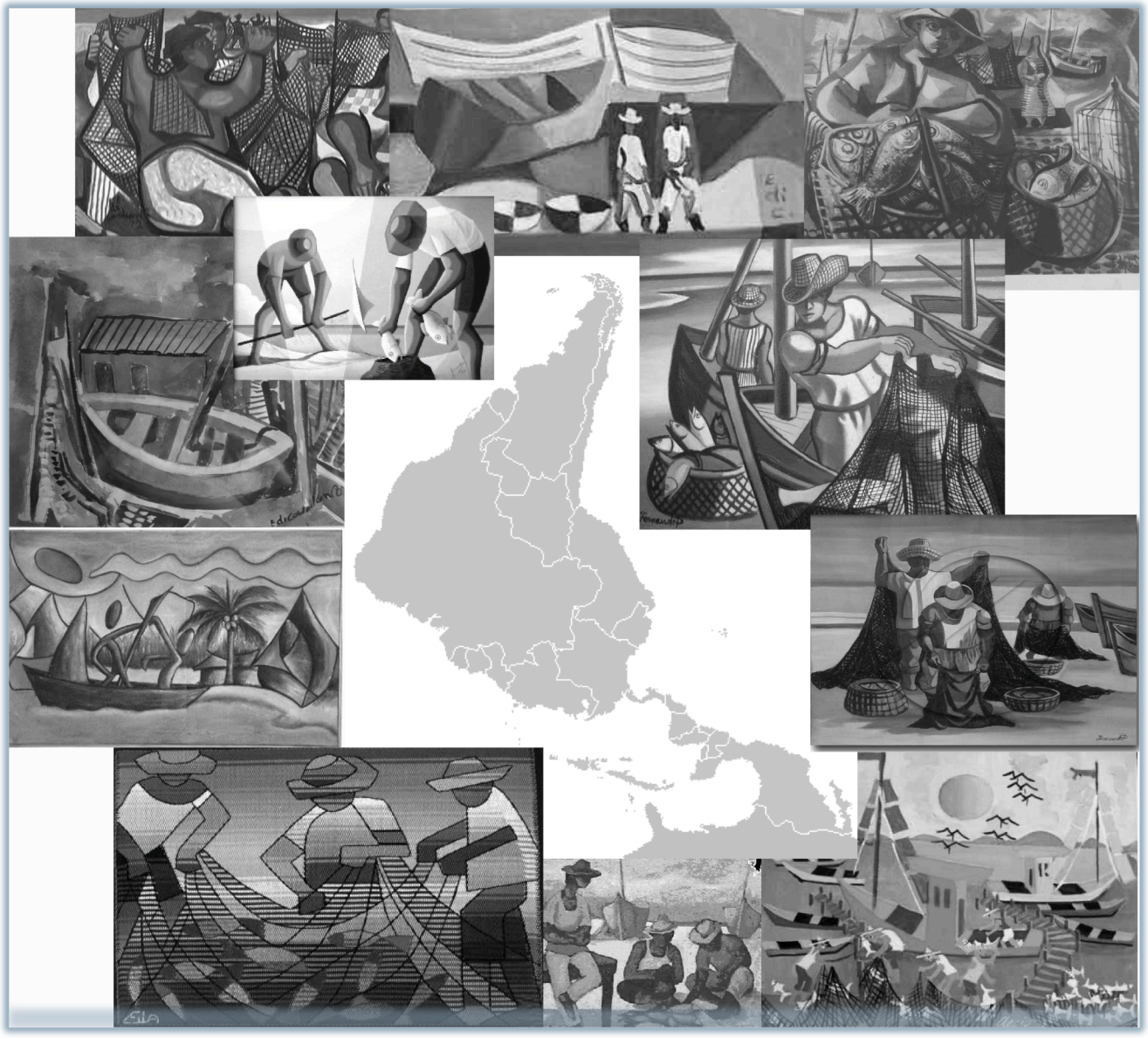

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COVER: M.A. Gasalla - Collage of consecrated paintings from Latin American artists and a Southern perspective on the continent.

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Enhancing stewardship in Latin America and Caribbean small-scale fisheries

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Enhancing stewardship in Latin America and Caribbean small-scale fisheries: challenges and opportunities

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Abstract

This thematic series, entitled "Enhancing Stewardship in Latin America and Caribbean Small-Scale Fisheries", emerged as part of a joint effort to bridge Latin-American scholars interested in networking on small-scale fisheries in the region. Built on results presented at two meetings ('Too Big to Ignore' (TBTI) Workshop in Curitiba, Brazil, and the 2nd World Small-Scale Fisheries Congress in Merida, Mexico), this issue combines a unique collection of emergent and pressing issues related to small-scale fisheries in Latin America. It comprises of theoretical, methodological and policy-related aspects across a range of topics such as co-management, biodiversity conservation, governance challenges, and territorial tenure, in seven countries - predominantly from South America. In this Introduction, we provide some background to the similarities and diversity within the Latin America and Caribbean region, and their relevance to small-scale fisheries stewardship. Subsequently, we briefly introduce the contributions that range from cross-scale governance in Chile, cooperativism in Mexico, species introduction in Bolivia, interactive governance in the Galápagos and co-management in Uruguay, Brazil and Colombia, to territorial losses in Brazil. Multiple contexts and processes, theoretical and analytical perspectives (multi-stakeholders, socio-ecological systems, cross-scale issues, territorial approach) are highlighted, as well as the policy challenges to safeguard small-scale fisheries from numerous pressures such as urbanization, industrial expansion, tourism, pollution, and conservation policies. This series aims at inciting further consideration of innovative perspectives to bridge local communities, academics, practitioners and policy makers in joint efforts to promote priority action on issues that require immediate attention and transdisciplinary multidimensional outlooks on that important sector.

Introduction

"Our America, the Patria Grande *(Big Motherland), has in its people, content and continent, sense and projection: an openness to the world. A world that needs our life's conception: the Brazilian, the Colombian, the Bolivian, the Chilean, the Uruguayan, and so on. But also all and each of our own and different ethnics that cross our nations, [...] show our colors, pigmentations, and transcendences. Thus, our Latin-American identity is and will be an identity opened to one's neighbor, and never be closed to the unknown or different"*

Rodó (1900)

This thematic issue, entitled "Enhancing stewardship in Latin America and Caribbean small-scale fisheries", emerged from a workshop in Curitiba, Brazil, organized by the global partnership for small-scale fisheries research 'Too Big to Ignore' (TBTI) (http://toobigtoignore.net) in 2013. Scholars from nine Latin-American countries were brought together to build a regional network for small-scale fisheries (Gasalla et al. 2013). The strong engagement of participants with local and community movements inspired this publishing project as an effort to offer a regional view on small-scale fisheries to a global audience. In addition, following the 2nd World Small Scale Fisheries Congress held in Merida, Mexico, three additional contributions were invited for this publication project. The final collection comprises seven original research articles and aims at flagging the awareness and some of the central ideas and values emerging in the region with regard to small-scale fisheries (SSF) in particular, but it also touches on regional identities and common challenges for natural resource governance in general.

Latin America and the Caribbean countries make a relevant contribution to global fish production and also to fish meal supply for aquaculture and animal husbandry, especially from ecosystems that have abundant fish stocks. However, small-scale fisheries provide a wider range of benefits for the coastal states of the Atlantic and Pacific oceans as well as for their multiple productive drainage basins. Although regionalization has gradually become a catchword in fisheries research and policies (Blount 2012), a regional perspective from Latin America and Caribbean (LAC) deserves some caution. The image of a unique LAC region is often contested due to its broad cultural diversity. Different ethnic traditions show ancestral connection with land and history, from more predominantly indigenous to more European-influenced regions. Hispanic and non-Hispanic countries, such as Brazil, sharply differ in colonization processes, as well as the heritage from classical civilizations contrasts with the alternative influence of Anglo-Saxon instrumental pragmatism (Lafer 2014). The quote above from the Uruguayan writer José Enrique Rodó still defines a peculiar South American vocation that puts in perspective both its peculiarities and zonal pattern. In addition to different imaginaries, the highly heterogeneous socioenvironmental and institutional contexts of small-scale fisheries require a focus on the large range of fishing production systems and social organizations, where a myriad of techniques, habitats, tools, target species, market and crew structures can be found (Salas et al. 2007). Finally, fish consumption varies remarkably across the region from high indices such as in Guyana (34 kg/person/year) and Panama (25 kg/person/year), to much lower figures where other animal protein sources are more easily available such as in Argentina (5 kg/person/year) and Honduras (3,5 kg/person/year) (FAO 2014; Flores 2014).

Notwithstanding their socioenvironmental diversity, Latin America and the Caribbean share important features and challenges which directly influence the pattern of small-scale fisheries. The historical legacy of invisibility of small-scale production systems, as well as the socioenvironmental impacts emerging from the neodevelopmentist model, are common denominators driving continuities and changes in small-scale fisheries in the region. SSF are a source of food and job security and support cultural reproduction and knowledge. They have supported a wide range of human groups since pre-colonial times. Recent archaeological research has revealed that fisheries were the main activity of pre-Colombian societies inhabiting the Amazon, providing long-term subsistence to large Amerindian settlements (Prestes-Carneiro et al. 2015). At present,

in addition to income and food for the rural (and urban) poor, SSF also provide goods for regional and international markets and ecosystem services from more sustainable practices (see e.g., Salas et al. 2011).

Despite their high social and economic relevance in the region, SSF have been characterized by a history of inequality and social exclusion. Small-scale fishers have outlived major transformations in the history of the region; however, they have always occupied a marginal position in national policies. As a result, they have survived mostly in more isolated places while they have gradually disappeared or been highly transformed with the emergence of more powerful economic actors. Only recently have fishing communities become politically more active in claiming their rights to fishing territories. Peace building, democratization processes, and the emergence of a new left in national governments in the last two decades have opened up new spaces for political organization and contestation in Latin America, and allowed fishing communities to build up social movements in order to safeguard their livelihoods (see e.g., Castro et al. 2016). As a result, they became key allies of transnational activism against damaging activities in and around coastal and riverine areas. Consequently, in some cases, land tenure regulations, social policies, and participatory initiatives have led to the transfer of some power to fishing communities to protect their territories.

This thematic issue of MAST focuses on this changing socioenvironmental context in the region. Democratization and economic globalization have reshaped the social configuration of small-scale fishers and fishing communities. On the one hand, the region represents a hotbed of institutional innovations regarding local governing systems to regulate access to resources. Traditional communities heavily dependent on fisheries often comprise a form of *de facto* tenure over fishing areas in the form of Territorial Use Right in Fisheries (TURF) (Christie 1992). In some countries, the national state has shown major efforts to incorporate traditional knowledge and institutions into innovative territorial and governance models (Begossi 2010). In addition, social policies such as conditional cash transfers and food security programs have driven a rapid decline in poverty and inequality, reaching the Millennium Development Goal prior to the target date (FAO 2014).

On the other hand, the position of small-scale fisheries in environmental governance is particularly challenged by the limited institutional capacity of the state and persistent elite power (Castro et al. 2016). In particular, development and conservation policies represent two antagonistic drivers that currently reinforce the historical structure of inequality and invisibility of the fisheries sector. Development has increased the impact on access to or productivity of traditional fishing territories through rapid urbanization processes, infrastructure development, tourism, fisheries intensification, aquaculture, and pollution. Conservation has reduced access to traditional fishing territories through the implementation of no-take marine protected areas. Squeezed between these two areas of policy, small-scale fishers have been facing increased loss of territory and reduced access to productive fishing areas.

In sum, the interplay between new opportunities emerging from the increased political mobilization and institutional innovation on one side, and new threats emerging from increasing coastal and riparian grabs, on the other, characterizes the current context of SSF in Latin America and Caribbean. The historical expansion of industrial activities competing with traditional livelihoods, and the concerns

about sustainability, lack of management, and the relatively low ingestion of fish protein, are regional aspects of the so-called global "fisheries crisis". Small-scale fisheries and the uncertainties about how they affect or are affected by changes in ecological and social system dynamics are key issues that require immediate attention (Gasalla et al. 2013).

Enhancing stewardship in LAC small-scale fisheries

The contributions that will follow this introduction come from seven Latin American countries – Chile, Mexico, Bolivia, Uruguay, Ecuador, Colombia, and Brazil - and take us through a myriad of socioenvironmental contexts, from the northern Caribbean Sea all the way to the south of Chile, from the Galápalos Islands on the Pacific coast, crossing the western Amazon, and reaching the Atlantic Ocean. The collection brings a number of theoretical, methodological and analytical approaches to address the multiplicity of contexts and challenges and highlights some possible solutions for the small-scale fisheries in the region undergoing rapid social and environmental change.

Gelcich et al. (2015) set the stage for coastal stewardship by offering a comprehensive overview of marine biodiversity conservation policies in Chile. As leading experts on Chilean TURFs, the authors focus on ancillary initiatives under the Convention of Biological Diversity as a strategy to scale up marine conservation and emphasize the relevance of cross-scale governance to enable this strategy. In particular, they emphasize the role of socioeconomic aspects and bottom-up processes in the siting of marine protected areas, and advocate participation of civil society at an early stage. Finally, they claim that a paradigm shift in marine conservation is needed in which the local communities that assume the costs imposed by conservation policies in their territories should be properly included.

The above conclusion is the departure point of Méndez-Medina et al. (2015) to outline a conceptual framework to analyse successful fishing cooperatives in Mexico. The authors initially provide an institutional ethnography and historical analysis of the Vigia Chico spiny lobster cooperative in Quintana Roo. Subsequently, they identify social, political and ecological drivers of their success: local social organization, resilience to perturbations, and the fishing concession process. The authors found that individual and collective livelihood goals beyond fishing as well as good articulation between local and scientific knowledge have strongly supported the successful performance of the cooperative.

Macnaughton et al. (2015) addresses a common problem in many freshwater systems, the impact of an introduced fish species. The authors showed the implications of introducing the large scaled fish *Arapaima gigas* (pirarucu or paiche) for an indigenous fishing community in the Bolivian Amazon. Based on resilience theory, the authors address the species introduction as an impact creating socio-ecological instability and driving the reorganization of the system. This highly economically valued species has provided both opportunities and challenges to the community. On one hand, it has provided an alternative economic source and triggered local organization to protect this community-based fishing territory. On the other hand, the introduction of this large predator seems to have had an impact on the diversity and abundance of other fish species and, in turn, has driven the formerly diverse small-scale fishing system to a

single-species intensified commercial fishery. To what extent these changes may affect the ecosystem and its social structure is still to be seen.

Paladines and Chuenpagdee (2015) assess the overall governance quality of the Galapagos Marine Reserve in Ecuador by applying the interactive governance perspective. This iconic protected area is characterized by a non-transparent decision-making process and is highly biased towards conservation policies. By focusing on the system-to-be-governed, the governing system, and governing interactions, the authors highlight the complexity, diversity, and dynamics of the study area and conclude that the low relevance of small-scale fisheries in the governance system limits the participation of fishers in the decision-making process and the accountability of this activity in the local economy. The authors conclude that only by taking into account the social component in the governing system can the marine reserve sustainability be improved.

Along the same lines, Trimble and Berkes (2015) address opportunities and challenges for co-management of small-scale fisheries in Uruguay and Brazil. In both case studies, the coastal communities rely on similar fishing resources, are undergoing socio-environmental crisis, and are moving from hierarchical governance to a more collaborative approach between local users and the state agencies. By using Ostrom's design principles, the authors assess the opportunities and limitations for building an effective adaptive co-management system in both sites. While the diagnostic approach of design principles is useful to reveal some institutional shortcomings in both cases, it lacks the analytical power to address more processual issues related to social learning and external drivers as observed in the case study.

Saavedra-Dias et al. (2016) address a less visible factor in co-management systems: the role of experts' opinion and the perceptions of key stakeholders in the Colombian small-scale fisheries on the Atlantic and Pacific coasts. Through a methodology combining interviews and workshops with three key stakeholders – fishermen, researchers and grassroots leaders – the authors identify points of synergy and conflicts across stakeholders and regions. The article sheds some light on the different images, values, and knowledge systems among key stakeholders and highlights the importance of developing some level of consensus in early stages of the co-management design in order to take socioenvironmental diversity into account and to enhance stewardship.

Lastly, in the final article of this thematic issue, Gasalla and Gandini (2016) illuminate power asymmetries in coastal zone management in Brazil and the territorial losses faced by small-scale fishers. The authors show the trend to coastal grabbing inherent in both development and conservation policies through the case of a typical shrimp fishery of the São Paulo coast. Through spatial analysis they estimate maritime territorial loss due to multiple policies and practices and discuss management problems and potential solutions. By bringing new meanings to maritime territories, that may be seen as spaces of reciprocity, food supply, and public-oriented communitarian work, they argue that environmental and fisheries stewardship should still make room for social justice and human rights.

Overall, the contributors illustrate the multiple and changing contexts and realities of small-scale fisheries in Latin America. Through a range of theoretical frameworks and methodological strategies, the articles highlight the main trends, threats, and innovations observed in the region. Historical analysis, cross-scale issues, territorial perspectives, socio-ecological systems, interactive governance and institutional analysis are

some of the analytical approaches used to address emergent challenges and opportunities for small-scale fisheries stewardship. Despite their diversity, all articles converge around the need for a more socially-informed governance perspective in which inclusiveness, interactions and stewardship are central elements. In particular, three key actors deserve close attention in the debate on small-scale fisheries stewardship in Latin America. First, the State has a contradictory role. On the one hand, it promotes socially inclusive territorial co-management policies, on the other, it hinders management by implementing conflicting development and conservation policies. Second, local communities and grassroots organizations have been instrumental in bringing traditional knowledge to the development of more sustainable territories and production systems. Local communities have struggled, however, to build their livelihood due to rapidly changing sociocultural, environmental and economic contexts. Finally, strategic actors such as academic institutions and activists have been instrumental in supporting knowledge building, network development, and political mobilization, but often are in conflict due to different images and concepts of sustainability, development and justice.

This collection raises also a series of pressing and emerging issues which have particular characteristics in the region such as coastal grabbing, introduced species, conflicting policies, multi-stakeholder networks and co-management models. In a context of a historical legacy of high inequality and dependency relations, weak institutions and political will, and limited concerted information gathering and monitoring, the relevance of initiatives rooted in the alliance between small-scale fishers, researchers and practitioners seems key to support institutional innovations for increased resilience of SSF systems. Such an analytical approach seems very useful and offers possibilities of effective dialogue and interchange on common issues that may be explored comparatively. New pressures from both developmentalist and conservationist policies, knowledge gaps and the fast pace of socioenvironmental changes should be balanced with social learning emerging from local empowerment, territorial and cultural rights, and knowledge building through partnerships. Despite the arguably artificial notion of homogeneity among Latin American and Caribbean small-scale fisheries, some observed commonalities are valuable starting points from which to build up a regional perspective for collective research, activism and policy agendas.

Our expectation is that this series can inspire further development of novel perspectives to be replicated, not as a blueprint model but as principles and guidelines from the improvement of small-scale fisheries elsewhere. Ultimately, the lessons from the case studies may also help to promote priority actions in LAC and beyond on issues that require a multidimensional agenda that better articulates economic, social, political, cultural, ecological, legal and ethical goals.

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Authors' contributions

The Editorial was equally divided between the two co-authors in conceptualization, writing and revision. MG outlined and wrote the first version of the Introduction section and FC complemented it with connections with the environmental governance debate. Brief description of each chapter in section Enhancing stewardship in LAC small-scale fisheries was equally divided between MG and FC. Final considerations (last two paragraphs) were outlined and written by FC and complemented by MG with connections with the debate on small-scale fisheries stewardship. Both authors read, revised and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

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Alternative strategies for scaling up marine coastal biodiversity conservation in Chile

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Abstract

The continued degradation of marine ecosystems, along with the ecosystem services they provide, suggest that new, innovative approaches are needed to scale up marine biodiversity protection and promote sustainable fishery practices. We synthesize information from Chile on the key processes involved in the development of alternative strategies for scaling up marine biodiversity conservation and discuss the complementarities with marine protected areas. Defined as "ancillary" marine conservation initiatives under the Convention of Biological Diversity, we suggest that these alternative strategies have the potential to capitalize on local stakeholders' participation and contribute to solving livelihood and governance issues while playing a significant role in scaling up marine conservation. We specifically focus on two recent ancillary initiatives being piloted in Chile. The development of business model innovations which could enable biodiversity benefits from territorial user rights fisheries policies and the creation of municipal conservation areas. We identify how these initiatives could eventually help scale up marine conservation, discuss opportunities and challenges from these pilot experiences and conclude with the need for developing policy frameworks and cross-scale governance approaches which formally acknowledge marine ancillary conservation measures as part of an integrated way to manage marine biodiversity. Exploring and supporting alternative complementary marine conservation strategies is particularly relevant in Chile and Latin America, if biodiversity conservation initiatives are to scale in coverage, contribute to livelihood improvement of local communities, replenish fisheries and play key roles in adaptation to climate change.

Keywords: Marine conservation; Territorial user rights; Navidad; Artisanal fishers; Municipalities; Marine protected area

Introduction

In 1992 the Convention on Biological Diversity set ambitious marine conservation targets, aiming to protect at least 10% of all marine ecological regions by the year 2012 (Wells et al. 2007). This target was not achieved and re-emphasised in 2010, with a new strategic plan to enhance international efforts at stopping degradation of the world's biological heritage termed the 'Aichi Targets' (CBD 2013). The target includes developing a network of well managed Marine Protected Areas (MPAs) defined by the World Conservation Union (IUCN), as any area of inter- or sub-tidal terrain with its overlying water, associated biodiversity, historical and cultural features, which has been

reserved by law or other effective means, to protect part or all of the enclosed environment (Kelleher 1999; Wells et al. 2007).

While the initial scientific focus for MPAs was on site selection (Turpie et al. 2000) and biological responses of species under protection (Micheli et al. 2004; Lester and Halpern, 2008), MPAs are now created not only to conserve seascapes and provide habitat for endangered sea-life, but also to contribute to the livelihood of local communities, to support national economies through tourism revenues, to replenish fisheries and to play key roles in adaptation to climate change, among many other functions (Watson et al. 2014). In this sense, multidisciplinary research efforts on MPAs have shifted towards defining conditions for effective management and enforcement. This has led to the recognition of the widespread occurrence of "paper-MPAs": marine protection occurs only in theory due to a lack of enforcement and management, due to the exclusive use of top-down implementation mechanisms, and lack of appropriate funding (Mora et al. 2006; Gravestock et al. 2008; Reid-Grant and Bhat 2009).

As a consequence, if marine conservation is going to effectively contribute to fulfill its multiple roles and also scale up and meet Aichi Targets, there is a pressing need to enhance the complementarities between MPAs and other management tools, by means of instruments that the Convention of Biological Diversity have termed "ancillary marine conservation initiatives" (CBD 2004). Ideally these ancillary instruments should allow participation of civil society in planning, implementing, and day-to-day management. Here, we synthesize information on two alternative strategies which could potentially serve as ancillary marine conservation instruments in Chile. We specifically explore business model innovations which could enable biodiversity benefits from territorial user rights fisheries policies (TURFs) and municipal conservation areas as ways in which Chile can scale up coastal marine conservation while securing coastal livelihoods and good governance.

Review

Chilean marine coastal conservation

In Chile, the main legal tools that exist for the implementation of MPAs take the form of Natural Sanctuaries, National Monuments, Marine Parks, Marine Reserves and Multiple use MPAs (Castilla 1996; Fernández and Castilla 2005; Castilla 2008). The goal of establishing Natural Sanctuaries, Natural Monuments and Marine Parks is to preserve natural ecosystems, while also allowing for educational and research activities. Marine Parks are non-take areas in coastal or open ocean waters where marine resources are off limits to any extractive uses. In contrast, Marine Reserves allow for the rational and sustainable exploitation of resources (Fernández and Castilla, 2005). Multiple Use MPAs have been the latest addition to the marine conservation policy instruments in Chile. Multiple use MPAs were first implemented with funding by the Global Environmental Facility, and are meant to act as an "umbrella-like" tool which considers the management of multiple ecosystem services within MPA boundaries (Gelcich et al. 2013).

Despite the existence of a suite of conservation tools, biodiversity conservation in Chile is underfunded, including MPAs (Castilla 2008; Gelcich et al. 2013; Waldron et al. 2013). Chile is one of four countries that are in bottom quartile of relative biodiversity

conservation funding and the top quartile of threatened biodiversity (Waldron et al. 2013). The inability to direct funds to regulate and enforce MPAs has been identified as one of the main causes that lead to their failure (Mora et al. 2006; Gravestock et al. 2008). For MPAs in Chile, revenues from tourism are not sufficient to finance running costs and enforcement. For example, *Lafken Mapu Lahual*, one of the largest multiple use MPAs in continental Chile, could only achieve around 10% of running costs, in the most favorable conditions, under current management scenarios (Gelcich et al. 2013).

Despite funding constraints, the number of MPAs has increased significantly in the past years. There are currently 22 coastal areas which are protected in continental Chile (Ministerio de Medio Ambiente, 2014; Figure 1). These account for approximately 900 km^2, which considers both coastal terrestrial portions as well as marine areas within the protected sites. Yet, there are still important gaps in surface and habitat representation of protected marine ecosystems (Tognelli et al. 2009). In response, the Environmental Ministry is considering the establishment of new multiple use MPAs as a way to scale up marine conservation efforts in coastal zones. In addition to the funding constraints, this strategy will be strife with additional challenges. For example, even at the current level of MPA representation, artisanal fishers have the perception that MPAs could cause conflicts due to issues around resource access (Gelcich et al. 2009a).

Budget constraints and low stakeholder buy-in represent two premier challenges for marine biodiversity protection in Chile and elsewhere. As mentioned, we discuss two approaches, namely, the establishment of business model innovations to incentivize biodiversity benefits form TURFs and the establishment of Municipal Conservation Areas, which attempt to overcome these challenges. The driving force behind these approaches is that if properly designed and supported, these ancillary measures could complement the Chilean network of marine coastal biodiversity protected areas (Castilla 2000).

Territorial user rights as possible ancillary conservation instruments

Chile is among the 10 most important countries in terms of fishery landings (FAO 2010). Thus, biodiversity conservation has to be scaled up in the context of an extremely productive marine coastal ecosystem (Thiel et al. 2007). In the last 5 years the total aggregated industrial and artisanal wild species landings, have ranged, around 4.5 million tons/year (Castilla, 2010). Approximately 50% of marine landings are based on artisanal fisheries operating in coastal zones (approximately <10 miles offshore; Castilla 2010). In Chile, to be classified as an "artisanal fisher", vessels must not exceed 18 m in length and have a maximum of up to 50 gross register tons (Fisheries and Aquaculture Law N^o 18 892; Castilla 2010). Within coastal zones, the artisanal fleet supplies a significant fraction of high-valued finfish, small-pelagic fish, benthic invertebrate, and algal resources. For instance, between 2005 and 2012 around 32,000 artisanal fishers registered as divers extracted about 245,000 tons $year^{-1}$ of benthic resources (excluding algae), worth approximately 340 $US million $year^{-1}$. (SERNAPESCA Servicio Nacional de Pesca 2005). Artisanal fin-fishers, during 2005–2012, extracted an average of 1.14 million tons $year^{-1}$of high value fin-fish and small-pelagic species, worth around 2465 US$/ton (SERNAPESCA Servicio Nacional de Pesca 2005). The artisanal fleet also lands about 373000 tons $year^{-1}$ of algae worth 250$US million $year^{-1}$ (SERNAPESCA

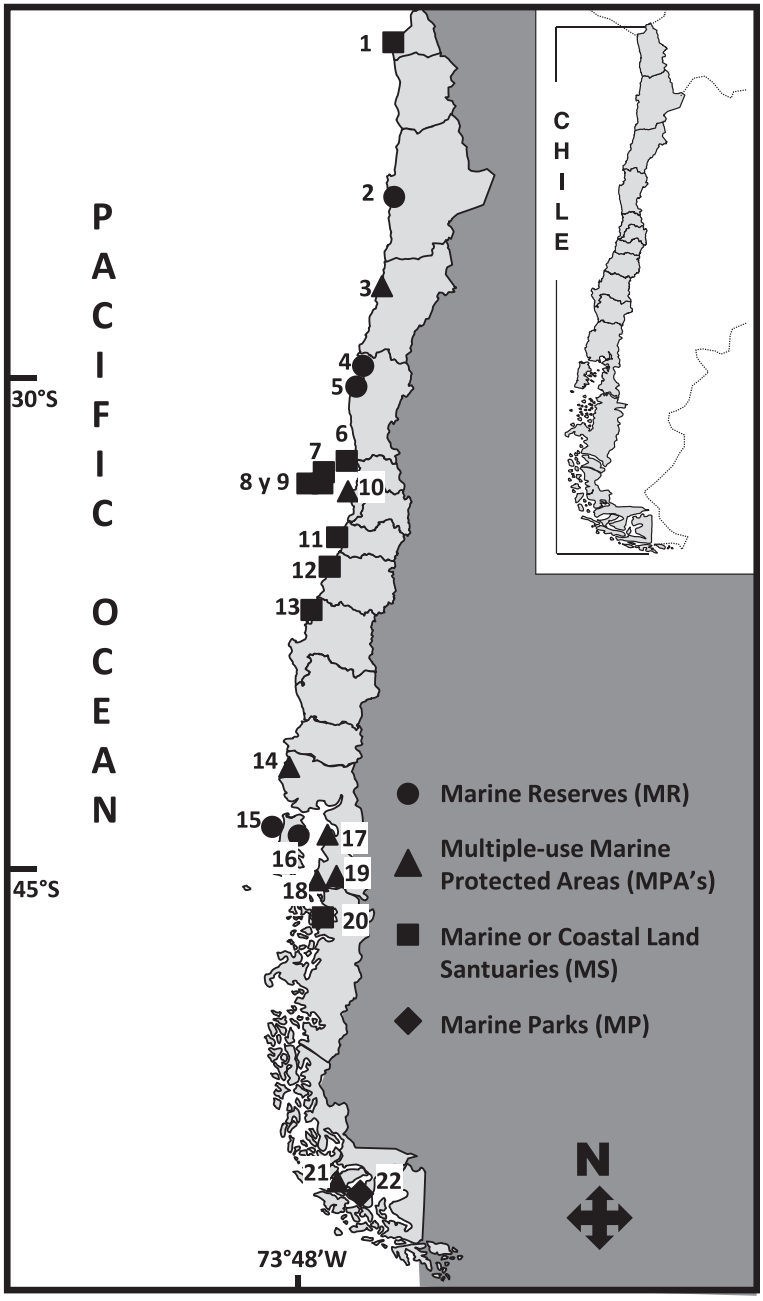

Figure 1 Map of Chile showing coastal protection areas which include marine and terrestrial ecosystems and their legal instruments. In the figure marine reserves (MR), Multiple use Marine Protected Areas (MPAs), Marine or coastal land Sanctuaries (MS) and Marine Parks (MP) are highlighted. Numbers in the figure represent: (1) MS Humedal de la Desembocadura del Río Lluta; (2) MR Bahía Moreno – La Rinconada; (3) MPA's Isla Grande Atacama; (4) MR Isla de Chañaral; (5) MR Isla Choros-Damas; (6) MS Isla Cachagua; (7) MS Roca Oceánica; (8) MS Islote Pájaro-Niño; (9) MS Peñón de Peñablanca; (10) MPA's Las Cruces; (11) MS Bosque de Calabacillo de Navidad (Municipal); (12) MS Roca de Constitución; (13) MS Lobería de Cobquecura; (14) MPA's Lafken Mapu Lahual; (15) MR Pullinque; (16) MR Putemún; (17) MPA's Fiordo Comau-San Ignacio de Huinay; (18) MPA's Pitipalena-Añihue; (19) MPA's Tic-Toc; (20) MS Estero de Quitralco; (21) MPA's Francisco Coloane; (22) MP Francisco Coloane.

Servicio Nacional de Pesca 2005). The legal framework (Fisheries and Aquaculture Law N° 18.892) that regulates fisheries in Chile provides a series of management policies such as marine zoning, regulating mobility of fleets, allocating exclusive territorial users rights for fisheries (TURFs), establishing management plans and establishing catch share systems for fully exploited species (Castilla 2010).

The TURFs policy implemented in Chile takes the form of Management and Exploitation Area for Benthic Resource policy (Castilla 1994). Through this policy the undersecretary of fisheries assigns exclusive access diving rights to fisher organizations (Castilla et al. 1998; Gelcich et al. 2010). The rational for establishing these user rights is based on common-property and co-management theories, which establish that securing access and sharing control over resources can create incentives for sustainable institutional arrangements among fishers, who will then manage and fish collectively and sustainably (Ostrom and Schlager 1996). In addition, it should contribute to more effective enforcement by increasing their likelihood of compliance (Jentoft et al. 1998). In order to be granted a TURF fisher organizations must actively engage in developing (with the help of biological consultants) official management plans. They are also responsible for surveillance and enforcement of anti-poaching measures (Castilla 2008). The first TURF was informally established in 1989 (Castilla et al. 1998). Currently in Chile there are 707 TURFs legally allocated to fisher organizations (Sernapesca 2010). Although there is heterogeneity in their performance, they account for more than 1,100 km^2 of the nearshore seascape, with an average size of approximately 100 h and an average distance between them of 4–10 km (Gelcich et al. 2010). TURFs are created and assessed considering economically important benthic species such as the carnivorous muricid gastropod *Concholepas concholepas* (considered in 80% of TURFs), keyhole limpets, *Fissurella spp*. (70%), and the red sea urchin *Loxechinus albus* (30%) and more recently for algae species (Castilla et al. 1998; Castilla et al. 2007). Biological studies of TURFs policy have proclaimed substantial increases of abundances and sizes of managed species within well enforced TURFs in comparison with open-access areas (Castilla et al. 1998).

In Chile the discussions on the role of TURFs as ancillary conservation instruments have historically been absent of the debate on scaling up marine conservation (Gelcich et al. 2011). Recently, the biodiversity conservation implications of TURFs began to be assessed scientifically (Gelcich et al. 2008, 2012). Results of these studies showed that TURFs can sustain densities and biomasses comparable to that of a fully protected no-take MPA for target species. TURFs also had significantly higher reef fish and macroinvertebrate species richness, biomass, and density compared with open-access areas (Figure 2). Furthermore, results suggest that the level of enforcement, aimed at preventing poaching in TURFs, is associated with biological diversity (Figure 2). Despite these benefits provided by TURFs for the subtidal communities, No-take MPA of around 20 hectares in size show higher density, biomass, and species richness of macroinvertebrates and reef fishes than TURFs, which indicate TURFs cannot replace no-take MPAs (Gelcich et al. 2012, Figure 2). In essence, biodiversity benefits from well managed TURFs are somewhere in between open access and No-take MPA levels.

The presence of TURFs, although probably providing fewer conservation outcomes than a no-take MPA, does allow marine conservation to scale-up in size. In continental Chile there is potential for conservation in 1,100 km2 of TURFs, with enforcement and

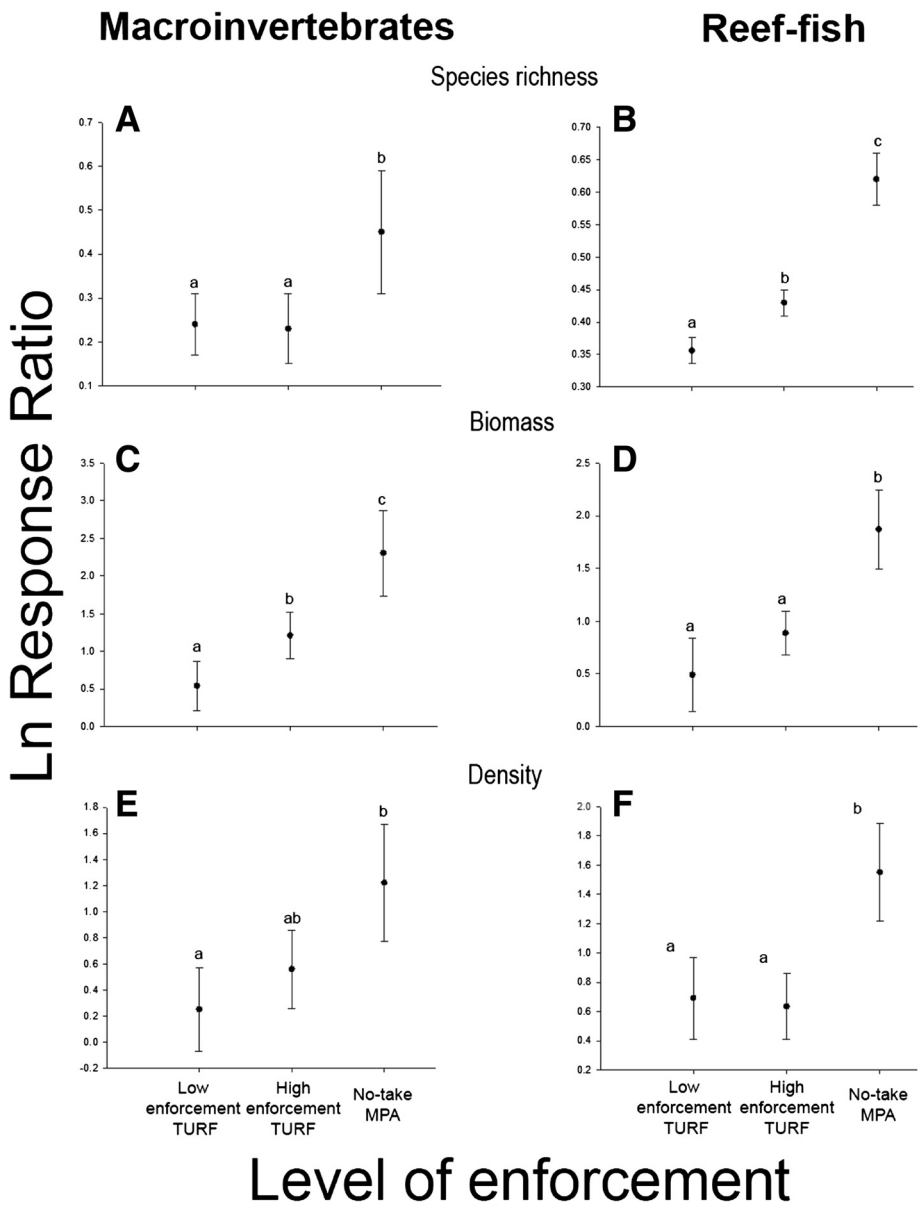

Figure 2 Response ratios for: (A) macroinvertebrate (≥3 cm) species richness, (C) macroinvertebrate biomass, (E) macroinvertebrate density, (B) reef-fish species richness, (D) reef-fish biomass, and (F) reef-fish density across different levels of enforcement of TURFs and the no-take MPA of Las Cruces. Response ratios represent the ratio of the specific measured variable in a given level of enforcement relative to the measured average value of that variable across 7 neighboring open-access areas. Hence, positive values of response ratios indicate greater species richness, biomass or density relative to open-access sites. 95% confidence intervals of response ratios were calculated with a 10,000-iteration bias-corrected and accelerated bootstrapping procedure. Letters above bars in each section indicate differences. The figure was constructed by the authors using the data reported in Gelcich et al. 2012.

surveillance in hands of artisanal fishers. There is also empirical evidence that the participation of fishers in TURFs has increased their stewardship capacity (Gelcich et al. 2008). Thus, it becomes imperative to assess and recognize the value of these ancillary measures in terms of effective marine conservation and to establish financial mechanisms to optimize their contribution (Gelcich et al. 2011).

An interesting model that is currently under consideration and analysis which could improve the potential of TURFs to scale up biodiversity conservation relates to the establishment of no-take zones within a portion of a TURF (Gelcich and Donlan, in press). Initial pilot case studies are being established to test this alternative, with promising preliminary results (Gelcich and Donlan, in press; www.advancedconservation.org). The aimed outcome of generating no-take MPAs within TURFs is a scalable program that can provide a supplementary revenue stream to fishers in exchange for management actions that produce enforced and verified biodiversity benefits, while also promoting sustainable fisheries (Gelcich and Donlan, in press).

Depending on how biodiversity incentive schemes are established, optimizing biodiversity within TURFs through establishing no-take zones within their boundaries can become a cost effective measure. TURFs hold the potential to enable at least two business model innovations that could improve fishers' livelihoods with biodiversity benefits. First, outcomes from conservation practices, such as the implementation of no-take areas within TURFs, could be commoditized and sold as credits in offset type markets (Gelcich et al. 2011, Donlan 2015). Because there are on-going marine and coastal impacts from the private and public sector throughout Chile, we anticipate opportunities for marine biodiversity offset programs. In fact, the Chilean government has recently modified important aspects of environmental impact assessment policy to allow offsetting. In addition, it is in the process of revising the offset framework within a new biodiversity and protected area policy. Second, biodiversity benefits from TURFs could be integrated and add value to products within emerging sustainable seafood markets (e.g., traceable seafood products with biodiversity benefits). Both these alternatives build upon basic conditions enabled by the TURFs, however to develop these concepts further requires the construction of learning platforms, collaborative demonstration-scale experimental trials where fishers, managers and scientists can co-construct the necessary knowledge.

Informing on innovative conservation approaches which are based on TURFs and their potential to scale up marine biodiversity conservation will require an understanding of biodiversity response, the development of financing strategies, which must be tailored to local realities, an understanding of the demand for biodiversity credits and fishers behavioral responses. New interdisciplinary approaches will be critical to solve these emerging research frontiers.

Municipal conservation sanctuaries as possible ancillary conservation instruments

Since the 1992 UN Conference on Environment and Development of Rio, international and national approaches to conservation have had to harmonize with social needs and the development agenda (Adams 2001). As a part of this process the concept of good governance of protected areas has evolved and is currently associated with fair methods, negotiation processes and the search for consensus among a plurality of actors and interested parties. This should result in building better bases for societal decision making (Borrini-Feyerabend et al. 2004). Concomitantly research and international *fora* have identified challenges related to promoting broad participation of interested parties in the management of protected areas and the fair and equitable distribution of the benefits derived from conservation (Adams 2001). A basic element of these

transitions is the principle of subsidiarity which holds that a larger and greater body should not exercise functions which can be carried out efficiently by one smaller, but rather the former should support the latter and help to coordinate its activity with the activities of the whole community. As a way to promote the abovementioned principles in conservation, the IV World Congress of Nature emitted resolution 4.037 regarding municipal conservation areas. This resolution urges the director general of IUCN to "recognize the value of Municipal Conservation Areas for biodiversity conservation and their importance for increasing the effectiveness of protected area systems; and develop the capacity to promote and assist initiatives involving members in the creation and strengthening of Municipal Conservation Areas through technical and financial support" (UICN Unión Internacional para la Conservación de la Naturaleza 2009 44–46). While municipal conservation areas can become a burden for municipalities who have no access to support networks and financial resources, the resolution establishes municipal conservation areas can become a suitable instrument for attempting to reach the goals of biodiversity conservation by linking conservation efforts with local needs. They also have the potential to contribute to efforts to generate more polycentric types of management for protected area systems (Ostrom et al. 1961).

In Latin America municipal conservation areas are relatively new phenomena, with only a few experiences which focus primarily on terrestrial environments from which to draw lessons (GTZ cooperación técnica alemana 2010). In Chile there is great potential to develop municipal conservation areas; there are 345 municipalities out of which 101 are in coastal zones (Gelcich et al. 2009b). In addition, Chile already counts with a National Municipality legislation named the The Ley Orgánica de Municipalidades de Chile, which requires that every municipality in the country establish a four year planning and management instrument, including comprehensive regulations, addressing the sustainability, rational management and conservation of resources and the environment within the municipality territories and/or ecosystems (Gelcich et al. 2009b).

Unfortunately, despite municipalities' potential in scaling up marine conservation, so far there is no clear legal approach through which municipalities can obtain management rights and funding to conserve marine areas, or is there a formal recognition of the role they can play for scaling up marine biodiversity conservation. Thus there is an urgent need to develop and support learning platforms and strengthen management skills, to highlight the real potential of marine municipal conservation areas.

One example of municipal marine conservation in Chile has been developed in Navidad, Libertador Bernardo O´Higgins Region, Chile. In Navidad, the local municipality, fisher unions and university academics began the process of applying for a no-take marine reserve in a united way in 2005. The initiative relies on collaboration of this diverse set of stakeholders that operate at different levels. The process of selecting sites and developing the base-line studies took approximately 4 years and was a collaborative process between fishers, academics and municipal officials. In addition, fisher union presidents, academics and the local council held meetings with all artisanal fishers with the objective of modifying and validating the results from site selection and base-lines (Oyanedel et al. 2015). Outreach of the final decisions towards the broader civil society was led by the municipality and fisher unions (Figure 3). In addition educational activities surrounding the sanctuary initiative have been a constant element (Figure 3).

Figure 3 Photo panel showing A) Informative panels that explain to the community and tourist about the marine conservation initiative carried by local fishers, the municipality and scientist of the Universidad Catolica de Chile. B) Opening ceremony where the Marine Municipal Sanctuary area of Navidad was officially established. **C**) Educational field activity developed by the Municipality for local students to learn about marine conservation. **D**) Outset of the "Alliance of Coastal Municipalities for Sustainable Development", where eight costal municipalities committed to work together to re-vindicate their rights to manage and conserve marine coastal environments.

The municipality-fisher-university collaboration brought new ideas regarding ways to conserve marine biodiversity, but more importantly, it brought in networks of contacts that help members of the fisheries union to access non-local institutions and resources (Gelcich et al. 2010). An analysis of communication, support and information networks of the Navidad initiative show how these three aspects were enhanced through the process of application and design of the marine sanctuary (Oyanedel et al., 2015). The fact that expanding and linking networks of exchange helps facilitate integrated and inclusive coastal management is not new. Tomkins et al. (2002) in Trinidad and Tobago show how those networks spread across national and international boundaries in ways that would have been hard for locals to do on their own. An important factor in developing this successfully is the presence of "linking organizations" between local actors and other scales of organizations. Linking organizations provide opportunities by bringing in resources, knowledge and other incentives to engage in marine conservation networks (Folke et al. 2005).

The Navidad marine Sanctuary is currently the first marine municipal conservation area in Chile. It was formally approved in 2013, eight years after the initial idea emerged from the fishers, municipality officials and university scientists (Oyanedel et al. 2015). The emergence and consolidation of the sanctuary demanded several collective action tasks (Ostrom, 1990). These include communication, coordination of actions, mechanisms for solving conflicts and information sharing. The organizational structure and the development of trust and reciprocity between stakeholders which emerged during the 8 years were instrumental in confronting this challenge (Oyanedel et al. 2015). In essence, these bottom-up partnerships for marine conservation did not emerge automatically in response to potential benefits. There was a need to address transaction costs associated to participation, communication and engagement disparities at local scales (Oyanedel et al. 2015).

The Navidad marine Sanctuary is not an isolated experience; there is an increasing interest for marine municipal conservation areas from mayors, local councilors and communities in Chile. For instance in Ancud, located in the Chiloe island, the local municipality with help from NGOs and the support of fisher communities established a binding municipal rule (Ordenanza Municipal in Spanish) to regulate access and visiting frequency to a penguin colony in its coastal zone. In addition, in other areas of Chile, artisanal fisher Unions have managed to summon several stakeholders to begin to locally work on zoning coastal areas, which can then be validated by Municipalities.

Experiences such as the ones above, in which coastal municipalities have engaged in marine biodiversity conservation, have triggered interest and support of other municipalities in Chile. As a product of this, on the 27th – 28th of January 2011 eight municipality mayors with their environmental specialists got together and formed the "Alianza de Municipios Costeros por el Desarollo Sostenible" (Aliance of Coastal Municipalities for Sustainable Development: Figure 3) an alliance which manifests its right to be recognized as managers of marine biodiversity and therefore a right to participate in designing marine public policy and coastal spatial planning (Gelcich et al. 2011). The alliance is open to new coastal municipalities in Chile wishing to collaborate. Ideally, this initiative could help inform legislation to acknowledge municipal marine protected areas as part of a future national system of protected areas and engage the international conservation community to support and finance the creation of capacities and social capital for their development.

Discussion and conclusion

Policy decisions regarding conservation and management of natural resources directly affect fishers and coastal inhabitants' ability to maintain their communities and livelihood. Traditionally, these policies have tended to be driven in a top-down manner and consider the biophysical aspects of management decisions first and the socioeconomic impacts secondly. Experience from Chile, presented in this paper, suggests that in order to effectively scale up marine conservation practices in order to achieve both international commitments and effective coastal governance it might be more effective to emphasize socioeconomic aspects and develop mechanisms that acknowledge participation of civil society early in the process.

Participation in MPA processes tends to promote desired changes by having community members empowered with a sense of ownership (Pollnac and Pomeroy, 2005). Research which has explored experiences from municipal conservation areas show that the collaborative work aimed at facilitating dialogue and solutions, which led to the establishment and implementation of the Navidad MPA, paved the way for a consolidation process (Oyanedel et al. 2015). However the widespread implementation of municipal conservation areas is challenging, common interests do not necessarily lead to successful implementation, funding constraints and the lack of capacities could jeopardize these initiatives. However, external agents can support these processes by facilitating dialogue and finding solutions (White and Runge, 1995).

Creating market (i.e., non-regulatory) incentives to establish enforced, no-take zones within TURFs presents an opportunity to integrate livelihood improvement and marine biodiversity protection (Gelcich and Donlan, in press). In principle, using this strategy

as an ancillary conservation instrument could apply to any small-scale TURFs fishery across the globe. Yet, not all TURFs are created equally, and they have been created mainly as fisheries management tools. Thus, exactly how a program can incentivize human behavioral changes to produce biodiversity benefits and how those benefits can be financed will depend on local social-ecological conditions. Important conditions which must be considered include the existence of latent biodiversity benefits and fishers' capacity to enforce TURF areas. Local enforcement by fishers not only requires a system of local governance and financial incentives, but also cross-scale linkages with regional and national institutions that can develop and support effective enforcement (Cudney-Bueno and X. Basurto 2009; Gelcich et al. 2010).

In essence, it is important to highlight that the recognition of ancillary conservation measures for marine conservation must be coupled and integrated to existing centralized experiences to achieve success. The dichotomy between top-down and bottom-up processes must turn into a synergy between these processes (Carcamo and Gaymer, 2013). In Chile evidence shows there is a strong potential for bottom-up processes in marine conservation, but there is also a need for top-down steering and guidance (Gelcich et al. 2009a). Cross scale linkages between scales of governance are crucial for the provision of services, goods and infrastructure related to the protection and enhancement of marine biodiversity, the economic development of community enterprises, and the political representation of communities (Grilo 2011).

Marine conservation in Chile is undergoing an important transformation. The newly elected government of Michelle Bachelet which took office in March 2014 has highlighted the need to establish a "National Service of Protected Areas and Biodiversity" which will gather and concentrate the diverse conservation instruments in both land and sea, under an integrated environmental governance scheme. This represents a key opportunity to highlight the role that ancillary conservation instruments such as TURFs and Municipal conservation areas could have in scaling up and managing marine biodiversity. This overarching national framework for conservation must also begin to consider the development of innovative financing mechanisms such as voluntary biodiversity offset programs (McKenney and JM Kiesecker 2010; Donlan, 2015) and market based mechanisms to finance conservation (Lester et al. 2013). The ancillary efforts presented here have the potential to enhance the overall governance of coastal natural resources and improve livelihood security of the people involved. Developing these issues further will require a planned research agenda including multidisciplinary teams, who must inform political discussions to generate the learning process for effective conservation of coastal zones.

By synthesizing information on the key processes involved in the development of pilot ancillary conservation initiatives, our goal has been to establish a better understanding of the broader foundations for innovating on ways in which marine conservation outcomes can be scaled up while accounting for local governance and livelihood realities. Important paradigm shifts which must be considered in a marine conservation agenda for Chile and Latin America must consider an evolution from conservation run by central government to that run by multiple-partners, including local communities, the private sector and NGOs. An evolution from conservation paid for by taxpayers to that paid for from multiple sources to achieve self-sustaining (Gelcich et al. 2013). Furthermore, a major shift is needed, signaling that marine

coastal conservation should not only benefit visitors and tourists, but also, local communities, which assume the opportunity costs of conservation. We advocate that acknowledging and developing the concept of ancillary conservation measures is one way of including these paradigm shifts in marine conservation policies, not only in Chile, but more broadly in Latin America.

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
All authors contributed to the review, drafted, read and approved the final manuscript.

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The Punta Allen cooperative as an emblematic example of a sustainable small-scale fishery in the Mexican Caribbean

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Abstract

We present an institutional ethnography and historical case study of the Vigía Chico fishing cooperative, located in the community of Punta Allen within the Biosphere Reserve of Sian Ka'an, México. The top producer of spiny lobster (*Panulirus argus*) in the state of Quintana Roo for over 30 years, this cooperative has been claimed as an example of a sustainable artisanal fishery. To better understand and assess this success story, we performed an in-depth study of multiple factors to analyze their influence on the cooperative's success. The indicators selected were level and form of social organization, resilience to socio-environmental perturbations, changes in fishing gear, and the fishing concession as avenue to cementing institutional success. We conducted ethnographic fieldwork over five months, complemented by an in-depth analysis of the cooperative assembly's minutes. We found that the knowledge the cooperative acquired of the functioning of Mexican public policies was a factor in their success. Cooperative leaders were able to translate that knowledge in ways that benefitted the cooperative, enabling them to build a set of policy-responsive operational rules that could be effectively applied to artisanal fisheries more broadly. The isolated conditions of the area and the presence of natural perturbations such as hurricanes forced the community to increase their willingness to cooperate, and improved their capacity to respond as a group to perturbations. These successes in turn demonstrated the value of cooperative approaches to achieve individual and collective livelihood goals, within and beyond fishing. Such approaches have been further enhanced by the incorporation of academic knowledge and scientific techniques. We conclude that Punta Allen is a successful example of a community that has managed to creatively engage public policy instruments and translate them into effective local practices, enabling organizational persistence despite repeated changes in policies governing fisheries in Mexico.

Keywords: Small-scale fisheries; Fishing cooperatives; Fisheries governance; Common-pool resources; Fisheries conservation

Introduction

In Latin America, most artisanal fisheries are degrading rapidly, provoking widespread concerns about overexploitation of fisheries resources (Defeo and Castilla 2005). Many of these fisheries began as open access regimes under national jurisdiction. Initially, products from artisanal fisheries supplied domestic markets. Once national markets were integrated into the global economy, fishery products became export commodities, which often resulted in overexploitation of the resource (Defeo and Castilla 2005;

Orensanz et al. 2013). Concerns over how to manage fisheries resources sustainably have resulted in intensive research interest in successful artisanal fisheries (Defeo and Castilla 2005; Gallardo et al. 2011; Gutiérrez et al. 2011; Orensanz et al. 2013).

One salient conclusion has been that rights-based management systems tend to function better for sustainable artisanal fisheries. Case study examples from Latin America illustrate the benefits of such systems, such as the Seris in Sonora, Mexico (Basurto et al. 2012; Orensanz et al. 2013), and the Juan Fernández Archipelago lobster fishery (*Jasus frontalis*) in Chile (Orensanz et al. 2013). Other rights-based systems studied include the Territorial Use Rights for Fishing in North Central Chile loco abalone fisheries (*Concholepas concholepas*) (Defeo and Castilla 2005; Gallardo et al. 2011; Orensanz et al. 2013), and the concessions of Central Baja California, Mexico (Orensanz et al. 2013; McCay et al. 2014). The Punta Allen spiny lobster fishery (*Panulirus argus*) in the Mexican Caribbean has also been extensively profiled (Seijo and Fuentes 1989; Schlager and Ostrom 1992; Seijo 1993; Defeo and Castilla 2005; Seijo 2008; Sosa-Cordero et al. 2008; Brenner 2010). On the other hand, rights-based management alone is not the key to successful and sustainable fisheries. Research has shown that if divergent interests among stakeholders are not reconciled, serious conflicts may arise, threatening both the resource base and local livelihoods. Examples of less successful rights-based artisanal fisheries include that for the sea urchin (*Loxechinus albus*) in Chile (Defeo and Castilla 2005), and the Galapagos sea cucumber (*Isostichopus fuscus*) of Ecuador (Orensanz et al. 2013).

The Juan Fernández lobster fishery in Chile shares some characteristics with the Punta Allen fishery. Both share informal territorial access rights. Local fishers designate individual fishing spots, and in both cases non-invasive fishing gear is employed. Both are single-species lobster fisheries, with the benefit of high commercial value. Both developed their fisheries in geographic isolation, a characteristic that forced them to adapt and respond to environmental perturbations as a group. Unlike in Punta Allen, however, in the Juan Fernández case, the government has not recognized the system of traditional rights. This renders their system vulnerable to the incorporation of disruptive, externally imposed rules (Ernst et al. 2013).

Gutiérrez et al. (2011) analyzed 130 cases of fisheries with community-based co-management, and found them to be a key management strategy across countries with different degrees of economic development (Punta Allen was included in the study). The authors found that the attributes contributing to co-management success are the presence of strong leadership, followed by the implementation of community quotas, social cohesion, and protected areas limiting access to non-group members. All these elements are present in Punta Allen. However, the presence of these attributes does not fully explain the success of the case study, either.

The example of the Maine American lobster fishery (*Homarus americanus*) (Ernst et al. 2013) contributes a few additional elements to the analysis of successful artisanal fisheries. The Juan Fernández, Punta Allen and Maine fisheries all feature informal territorial rights. Maine lobster fishers access a common territory, in contrast to the two other cases, where fishers hold rights to specific fishing locations individually (Ernst et al. 2013; St. Martin 2001). In Maine, a well-rooted conservation ethic among local fishers in the industry resulted in laws that heavily support and facilitate resource conservation. For example, these laws established minimum and maximum lobster size measurements for extraction, a prohibition on the extraction of "berried" lobsters (egg-carrying females),

and the use of non-invasive fishing gear. The most important aspect of the above-mentioned laws is their compatibility with existing territorial systems (Acheson and Brewer 2003), a characteristic that the Maine fishers share with those of Punta Allen. This successful integration of local rules with law and policy—in conjunction with factors such as relatively easy access to high-market-value species and isolated geographic conditions—have resulted in a very particular form of social organization. That organizational form represents the essential ingredient in the maintenance of a system of rights that sustains the life of the fishery developed by the Vigía Chico Cooperative of Punta Allen in the Mexican Caribbean. Tracing the evolution of these distinctive conditions in the Punta Allen case thus has the potential to inform both artisanal fisheries management policy, and community practice in far-flung locales.

Setting the scene

In Mexico, fisheries are listed as secondary activities in State development strategies because of their minor contribution to the Gross Domestic Product (GDP). Nonetheless, small-scale fisheries make significant economic contributions. According to official data, in Mexico 70 % of fisheries resources are fully exploited, 10 % are in potential development and 20 % are in or close to collapse (Arreguín-Sánchez 2006). Artisanal fisheries in the country represent a huge management challenge. Catch levels are not fully recorded, and poaching and violation of closed seasons occur along the coasts of Mexico. The role of artisanal fisheries in the worldwide fishery crisis is often ignored or regarded as marginal compared to the effects of industrial fishing (Defeo and Castilla 2005). Nonetheless, small-scale overfishing can lead to serious local environmental and economic consequences.

In the Southern Yucatan Peninsular state of Quintana Roo, fishing has major social, political and commercial significance. Along the state's 900-km coastline, social life is organized by a system of artisanal fisheries. Experts consider these fisheries to be highly organized, second only to those of Baja California, nationally (Hidalgo and Méndez 2007). The system is dominated by cooperatives formed by local fishers, with little involvement of the outside commercial sector (Sosa-Cordero and Ramírez-González 2001). The fishery resources that historically have had the greatest economic significance for the state are the spiny lobster (*Panulirus argus*), shrimp (*Farfantepenaeus brasiliensis*), and the queen conch (*Strombus gigas*). Spiny lobster production has significant economic importance for Quintana Roo. From 2000 to 2008, 165.1 tons were produced (counting both tails and live lobsters). The catch represented six percent of the state's fishery production; fisheries, in turn, represent 40 % of the state's total gross product (Sosa-Cordero 2011).

There are three fishing areas in the state: North, Central and South. Each area has different levels of development, habitat characteristics and types of fishing gear employed in lobster catching. In the Central area, the focus of our study, the predominant types of gear used are *sombras,* or shades[a], and *jamo*[b], a type of net (Seijo 2008). This area includes the bays of La Asención and Espíritu Santo, both located with the boundaries of the Sian Ka'an Biosphere Reserve.

Spiny lobster abundance was a decisive factor and one of the principal drivers of the formation of the first cooperatives in Quintana Roo in the 1950s (César and Arnáiz

1986). After the 1970s, the activity lost importance in Federal development strategies (Sosa-Cordero and Ramírez-Gonzalez 2011). When conservation emerged as an important issue in Federal environmental development concerns in the 1990s, lobster fishing was identified as a threat to the Mesoamerican Barrier Reef. Fisheries became a key target of State strategies for coastal management (Velez et al. 2014). These changing socio-environmental circumstances make the lobster fishery of Punta Allen a valuable case study. Despite these apparently adverse conditions and the increasingly bleak scenario of many fisheries globally, the cooperative has emerged as a success story.

The Vigía Chico lobster cooperative of Punta Allen is located in what is today the Sian Ka'an Biosphere Reserve. As an instance of a sustainable artisanal fishery coexisting with marine conservation, the case has been frequently analyzed. The establishment of property rights over marine space and the efficacy of cooperative members' harvesting techniques have drawn the attention of many researchers (Seijo and Fuentes 1989; Seijo 1993, 2008; Defeo and Castilla 2005; Sosa-Cordero et al. 2008; Brenner 2010). To better understand the cooperative's success, we employed a historical perspective and an ethnographic lens. This combination of approaches facilitates an analysis of the community's interaction with changing state policies and institutions.

The lobster fishery of Punta Allen has been studied previously using an institutional analysis framework (Seijo 1993; Cochran 1998). The framework analyzes how collectively managed fisheries function, how group members are accepted or rejected, and whether possession of these rights to common property permit or prohibit the holder's sale of the resource. Institutional analysis is a well-recognized analytical approach. It defines institutions as the shared conceptions that humans use in recurring situations, which are organized by rules, norms and strategies (Ostrom 2007). By the term rules we refer to:

> "The result of implicit or explicit efforts by a set of individuals to achieve order and predictability within defined situations by: (1) creating positions (e.g., member, convener, agent, etc.); (2) defining how participants enter or leave positions; (3) agreeing on which actions participants in these positions are required, permitted, or forbidden to take; and (4) stating which outcome participants are required, permitted, or forbidden to affect." (Ostrom 1986:5).

We can see examples of these operational rules when fishers specify what types of fishing gear are permitted within a fishing ground (Schlager and Ostrom 1992:251). The rules that create and enforce property rights regimes play a primary role in institutional analysis. Rules can also be understood as the variety of rights and their allocations to particular stakeholders or categories of stakeholders (Poteete 2010). We understand "rights" as particular actions that are authorized (V Ostrom and John 1976). Rights are a product of rules, and thus not equivalent to rules (Schlager and Ostrom 1992). The institutional analysis framework has been invaluable in understanding the organization of fisheries and other governance regimes around the world (Schlager and Ostrom 1992; Jentoft 2004; Basurto and Coleman 2010; Gallardo et al. 2011; Basurto et al. 2012).

By employing a historic and ethnographic approach to the Punta Allen case, we seek to deepen the understanding of how this common property right of use has come into existence. The factors affecting contextual emergence of common property rights of use remain a vital question (Kadekodi 2004), and the principal concern of our paper.

Methods and study area

We conducted our case study on the Javier Rojo Gómez fishing colony—the official name of Punta Allen—within the perimeter of the Sian Ka'an Biosphere Reserve, Quintana Roo, Mexico (Fig. 1). Demarcation of the Sian Ka'an Biosphere Reserve began in 1982. It was gazetted in 1986, in a process led by the Research Center of Quintana Roo (CIQROO) with support from the National Council of Science and Technology (CONACYT). At the time of its demarcation, the only human settlements recognized within its boundaries were Punta Allen and Punta Herrero. Today María Elena, another fishing camp belonging to the Cozumel fishing cooperative, is also recognized.

The Sian Ka'an Biosphere reserve has an area of 652,193 hectares, of which approximately 120,000 are marine. The marine portion includes an 110 km-long continuous barrier reef, which makes it a focal point for the preservation of coastal ecosystems. This position also makes the territory of Sian Ka'an a priority focus for the tourism industry. The reserve encompasses a transition zone between terrestrial and marine ecosystems, containing an extraordinary diversity of environments in good condition. However, its poor soils are not suitable for agricultural activities. Due to a warm and humid climate, the region features mesic forests, flooded forests and mangroves (INE 1996). Hurricanes, northerlies (*nortes*), and droughts periodically affect the area.

For many years, the extraction of gum (*chicle*) was the main productive activity in the region, together with timber extraction and copra plantations for coconut oil production. Between 1960 and 1980, timber extraction faltered before an increasing scarcity of commercial timber species, due to overexploitation, and the chicle bubble popped with the emergence of synthetic gum. Copra production declined precipitously due to "lethal yellowing", a viral disease of the coconut palm. Given this grim economic scenario, local populations began to exploit marine resources through fishing. To ensure their resource use rights, in 1968 they established the "Vigía Chico Cooperative Society for Fishery Production" (Sociedad Cooperativa de Producción Pesquera Vigía Chico), followed in 1970 by the "Javier Rojo Gomez Fisheries Camp" (Punta Allen) in Ascension Bay (Brenner 2010). Today Punta Allen is highly dependent on the extraction of fishery resources (primarily spiny lobster) and tourist activities. In Ascension and Espiritu Santo Bays (located at the center and south of the Sian Ka'an Reserve, respectively), the use of *casitas,* or capture shades, and *jamo* as fishing gear currently dominate (Seijo 1993; Sosa-Cordero et al. 2008).

Ethnographic fieldwork was conducted from February to May 2013 and in July of the same year. The first author conducted in-depth interviews with 30 members of the cooperative, using a snowball sampling technique (Biernacki and Waldorf 1981). Guest et al. (2006) recommend conducting 30 to 50 interviews to allow the ethnographic researcher to achieve saturation of information on a particular topic, while capturing variability, for the proposes of thematic analysis. The first author interviewed current leaders of the lobster cooperative, as well as founding members, and accompanied some of them during their working hours (both off-season and in the fishing season). During ethnographic fieldwork, she spoke with leaders of the cooperative, and with some of the families opposed to the current Board of Directors, to triangulate the degree of legitimacy of the shared access rules. Ethnographic fieldwork additionally included interviews with residents who were not current cooperative members. The first author conducted four semi-structured interviews with officials of the National Commission of Natural Protected Areas (CONANP), and one informal anonymous interview with an official of the National

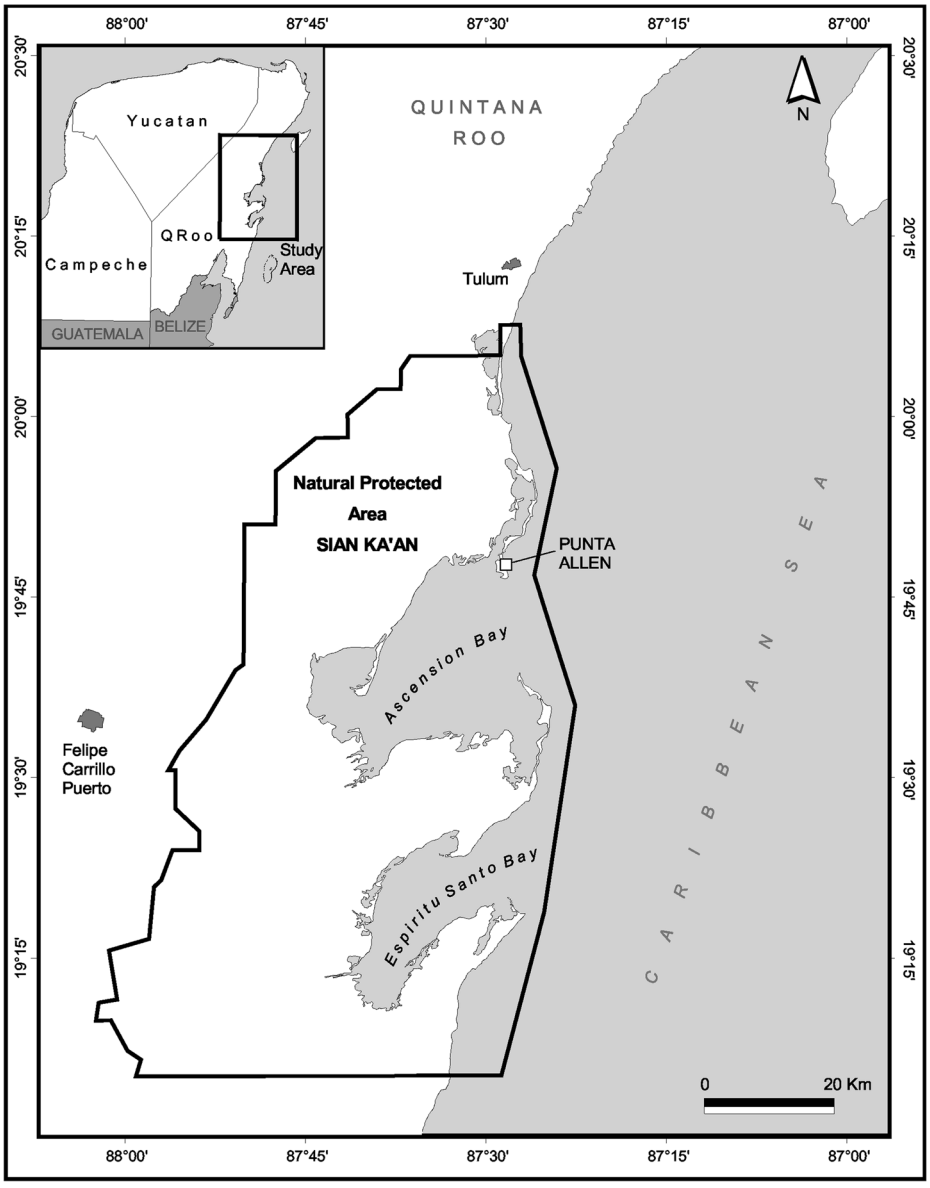

Fig. 1 Study area, showing location of the Sian Ka'an Biosphere Reserve

Committee for Fisheries and Aquaculture (CONAPESCA). She also interviewed members of non-governmental organizations working in the study area. Finally, she interviewed three fishermen who no longer live in the community, but who had been founding members of the cooperative.

We conducted a review of the cooperative's historical documents, including records of the assemblies and meetings of the Board of Directors during the cooperative's first 20 years of existence. We triangulated this information with a review of historical literature covering 100 years of public policy in Mexico. This enabled us to situate our understanding of the process of cooperative decision-making over time. We also traced how informal institutions and relationships between Punta Allen's Vigía Chico Cooperative and a variety of state-level stakeholders developed.

Historical review of coastal settlements

The lighthouse keepers: the basis of social organization

The first settlers of the eastern coast of the Yucatan Peninsula (presently the State of Quintana Roo) were descended from the Chontal, a Mayan ethnic group. The Chontal brought their prowess in navigation from the State of Tabasco, enabling them to master the coast and coastal waters (César and Arnaíz 1990). During pre-Columbian times, salt production and fishing were the main productive activities in Yucatan. Dating well back into the pre-Colombian era, cultural exchange and trade existed throughout the Caribbean (Thompson 1979). During the era of conquest English and French pirates from the Caribbean islands repeatedly attacked the coast of Quintana Roo, making the rapid settlement of the area by other Europeans impossible. Nevertheless, the Maya were able to establish trade agreements and alliances with the pirates. These relations were retained during subsequent periods of repopulation.

Throughout the nineteenth century, the Yucatán Peninsula witnessed numerous battles between incoming settlers and the Mayan residents. The most significant conflict in the area's history was the Caste War (1847 to 1901), which lasted more than half a century. At the end of the Caste War the population, who had fled the region for decades, began to return. Repopulation began in the south of the state and was made official with Mexican state promotion of the establishment of Rancho San Miguel (now Cozumel Island). Subsequently the municipality of Isla Mujeres was established on the eponymous island—named for its cultural importance as a site of Mayan women's rites of passage—and adjacent mainland. Regional resettlement occurred very slowly, as the territory was isolated from the rest of the country, and navigating the Caribbean waters remained difficult because of long hurricane periods (César and Arnaíz 1990).

At the beginning of the 20th century, the Mexican government established a Navy presence along the coast. The Marine Corps recruited local fishermen from nearby Isla Mujeres (César and Arnaíz 1992), who took advantage of local food resources like sea turtles, and practiced small-scale fishing while simultaneously protecting Mexico's southern border. The establishment of lighthouses was another piece of the government's strategy to secure and populate Mexico's southern border, thereby integrating this marginal territory into the nation-state. Those in charge of the lighthouses became the region's first non-Mayan settlers, and extracted copra. These settlers earned their living as farmers, fishers, and hunters, and created a form of social organization in the territory based on extractive and farming practices (César and Arnáiz 1986; 1990).

The presence of lighthouse keepers along the coast was essential for the consolidation of the social organization of most of the fisheries in Quintana Roo, and remains so today. Punta Allen was part of that early-20th century network of lighthouses. Among the records of the first lighthouse keeper we found the first formal proposal of how life and work in the settler community should be organized. The Punta Allen fishers' cooperative initially operated out of the lighthouse keeper's ranch, and one of the current cooperative leaders is that founder son.

Fisheries in Quintana Roo: the early years

During the early decades of the 20th century, the population living along the coast of Quintana Roo remained fairly isolated from the rest of the country. Socio-economic

exchanges happened through contacts with Cuban and Belizean fishermen, who arrived by sea. Local populations traded lobster with the Cubans and Belizeans for scarce staples like sugar, alcohol, salt and oil, transforming a product used for local consumption into a commercial commodity with high economic value. During these early years of the lobster fishery anyone could harvest lobster without restrictions; most extraction happened in areas close to the coast and reefs. Given resource abundance, lobster fishing was easy and required little effort. As commercial exploitation increased, interviewees say that the Cubans explained to one of the fishers how to use capture shades (*sombras*) to make lobster fishing more economically attractive and labor-efficient.

At the national level, fisheries were consolidated during the 1930s and 1940s. Nationwide, the 1940s and 1950s were of great importance for the development of the fishing industry. For Mexico, the Second World War boosted the fishing industry, creating an increased demand for seafood products for the U.S. domestic market (Cruz-Ayala and Igartúa-Calderón 2006). The introduction of diesel engines into local fishing practices represented an adaptation of military technologies to civilian uses after WWII. During the 1940s and 1950s, the government also promoted nationwide migration from urban centers to coastal areas. As part of a territorial reorganization plan, government policy concomitantly supported major investments in port infrastructure (Soberanes Fernández 1994; Cifuentes-Lemus and Cupul-Magaña 2002). In Quintana Roo, however, fisheries did not gain economic importance until after Hurricane Janet, in 1955 (César and Arnaíz 1990). After Janet hit the coast, most of the region's coconut palms were destroyed. Copra extraction ceased to be economically viable, and the territory's economic identity had to be redefined. The first fishing cooperatives of Quintana Roo were formalized during this time. Although initial efforts to encourage the creation of productive groups were made during the government of Lázaro Cárdenas (1934–1940)[c], it was not until the mid-1950s to the late 1960s that extractive practices were organized by Cooperative Societies for Fisheries Production (César and Arnáiz 1986).

Drivers of success

Social organization

The Punta Allen community was established under particular socio-geographical conditions. State development plans did not include significant infrastructure development in the area, so the first inhabitants had to travel long distances on rough roads to reach major regional urban centers like Felipe Carrillo Puerto and Chetumal. After copra plantations began to decline in the 1950's, fisheries came to the fore as an important economic activity in Quintana Roo. During the early years of settler community formation, this isolation from the rest of the territory was decisive for the practices of production and consumption enacted by fishing families and the few other individuals who lived in the community.

The first settlers belonged to three extractive traditions: copra, the quintessential coastal agriculture; fishing, practiced by fishers in Cozumel and Holbox, some of whom who traveled to Punta Allen to continue plying their trade; and finally, other agricultural and forestry traditions. One of the most important activities in these first years of the settlement (1950's-1970's) was crocodile hunting (both of the American crocodile, *Crocodylus acutus* and Morelet's crocodile, *Crocodylus moreletii*). A few lobster fishers

participated in this activity and sold crocodile meat and skin in Chetumal. Also, some new settlers worked exclusively in the manufacture of fishing shades and cutting chit palm (*Thrinax radiata*), used to construct the first shades and for roofing houses.

In this isolated settlement, social life was organized collectively; the few women living there washed and cooked as a group. The group's representatives in charge of marketing the product outside the community were responsible for bringing back basic supplies. Some fishers' wives accompanied their husbands on fishing trips, and prepared food along the way.

During the early years of the cooperative in Punta Allen, lobster was distributed to the city of Chetumal by sea, or was transported overland via a truck whose winding route ran from the Vigía Chico Carrillo harbor and could take 2 or 3 days because of the hostile terrain. Once the distributors managed to get out to the main road, the product was brought to Merida, Chetumal and Felipe Carrillo Puerto. Along with lobster, they transported turtle meat, one of the most popular seafoods at that time. Some trips went as far as the Mexico City.

Control over access to common resources was organized from the early days of the cooperative into three production groups, centered on three individuals with high leadership capacity. Though the early leaders had different views on how the fishery should be organized, the aforementioned conditions of geographic isolation, scarcity, and rough roads forced them to combine their efforts to market the product and purchase the products necessary for Punta Allen families' subsistence. These leaders started families in the town, and today remain the power holders in the community. The first leader, a founder of the community, came from a family of Spanish origin. He had little formal education, but was highly skilled in the management of economic resources. The second leader was the descendant of fishers who had participated in the formation of the Cozumel cooperative, which he left due to a conflict. He was the driving force behind the formation of the cooperative as the local mode of labor organization. The third leader was known in the community for his conciliatory capacity. He came from the area's farming tradition and was the individual who conducted negotiations and mediated between the community, NGOs and the government during the early years of the community and cooperative.

At this time, a local fisher deployed the *sombra* technique introduced by the Cubans. The new technology involved investment in materials, manpower and time during the lobster harvest, and thus disputes over resource ownership emerged. The first fisherman to place a capture shade into the sea was followed by other fishers, who noted where he was placing them with the intent of later stealing his catch. Another fisher followed suit, placing his own sombras, but they suffered the same fate, and his catch was stolen. These events were the genesis of the marine tenure system characteristic of Punta Allen. The catch-stealing problem was resolved by a fisherman who had previously worked as a farmer in the municipality of Felipe Carrillo Puerto. He decided to establish a fishing zone as a "*parcela*[d]", bounding an area of marine space. Other fishers imitated him and established that each fisher would have an assigned area in the sea for lobster fishing, in which he could place shelters to catch lobsters, just as a farmer would install infrastructure on his land. People in Punta Allen do not say that they fish lobster; instead, they harvest lobster. This apparently minor linguistic shift carries important symbolic weight in their fishing practice.

Once the cooperative was formed, extractive practices continued to be organized in working groups. In the process of delimiting lobster fields, fishers who belonged to one of the three major groups managed to defend their chosen marine territories and consolidate their ownership.

> "When we began to divide the sea… it was terrible, there were fights in the cantina. So that it wouldn't go on for too long, I made groups… you know, don't grab this plot just for yourself, divide it among four; so, when someone fights with you, you are going to fight as a foursome…whereas if you were alone, they would plaster you in the cantina. They made groups… [so now] you are talking about how you are going to fight six people, and it [acts as a deterrent]… I do not know if you understand how the strategy works…" (Rodrigo, founder, member of the Board of Directors, personal interview, April 20, 2013).

As the years passed and the cooperative matured, the families of these three leaders became the community leaders. They were responsible for negotiations with governmental institutions, participation in academic projects, and decision-making on how access to resources in the zone was allocated. Since the cooperative's inception, Mexico's Federal Cooperative Law (1938) served as a basis for regulating practices within the community. However, this was not an easy task. The low level of formal educational level of the majority of the fishers in the cooperative and the isolated geographic conditions spawned constant trips to the State capital (Chetumal) to ask government authorities to serve as arbitrators in many disputes. These iterative learning interactions with the State began to confer legitimate power on these leaders, who held administrative positions on the Board of Directors.

> "Before, no, we did not carry out our responsibilities because we didn't know about the performance of our activities, our responsibility… we always went and were told 'that's what conciliation and arbitration are for, conflicts.... The surveillance guy, that's his job to see that all the committees work well, and [bring to the Board's attention] those that don't, those are your duties'…" (Rodrigo, founder, member of the Board of Directors, personal interview, April 20, 2013).

This reinforcement of the legitimation of local authority figures via state backing helped ensure that interpretations of the Cooperatives Act would become instrumental to the regulatory practices of the community. This process further promoted the cooperative as the dominant form of community social organization. Notably, tourism, which has become an important economic activity in the community, is regulated by these same cooperative rules. The original leaders of the lobster cooperative continue to hold power in almost all spheres of public life, and the descendants of these leaders sustain this system of concentration of power.

Governmental organizations collaborate with the cooperative because of its implementation of sustainable extractive practices and its participation in the policing of marine conservation at a low cost to the State. Local fishers have firmly supported the surveillance system because the Ascension Bay fishing concession, which was granted by the State, provides them with security over the resource and protects their internal system of regulation.

In 1992, the cooperative's exclusive right to the fishery resource was eliminated by changes in State policy during the Salinas de Gortari government (1988–1994). At that time, the Fisheries Act was modified to include active private sector participation in fishing extractive activities. Species reserved for exploitation by cooperatives disappeared from the Act and a new regime was designed to grant concessions, permissions and authorizations, whereby these rights of use could be transferred to private investors. Additionally, early bids began for the sale of the state-owned enterprises Ocean Garden and Mexican Fishery Products (Soberanes Fernández 1994; Cifuentes-Lemus and Cupul-Magaña 2002). Even though cooperatives lost exclusive fishing rights under these changes in national fisheries legislation, the cooperative continues to be the only way the Punta Allen community can conceptualize the social organization of labor. The cooperative was able to maintain and consolidate power, because since its early days the founding leaders had respected state regulations, and used them to legitimize their decisions. Through their repeated consultations with regional authorities, and long-time adherence to State regulations, these leaders had strengthened their connections with state agencies and actors in ways that continued to benefit them, and offer legitimacy, despite the changes in legislation.

Responses to socio-environmental perturbations

When Hurricane Gilbert hit the coast of Quintana Roo in 1988, just 2 years after the formalization of the Biosphere Reserve, the course of local fisheries changed unexpectedly. The model of fishing had shifted at the federal level, with the 1983 implementation of the Exploration and Assessment of Fisheries Resources of the Exclusive Economic Zone and Territorial Waters program, a multi-agency and industry partnership[e]. Its intent was to estimate the resources that Mexico could extract from its exclusive economic zones and territorial waters. With this measure, the State changed its discourse from one of resource protection and regulation to one of deregulation. For each newly inventoried marine resource, trade values were assigned, and changes were introduced to fisheries legislation to encourage the participation of the private sector, as well as foreign companies (Soberanes Fernández 1994). The State also conducted an inventory of state-owned assets and commenced their sale. Multiple interviewees reported that before 1988, state-owned Mexican Fishery Products and Ocean Garden had been economically important, and responsible for most of the processing and distribution to packing companies in Quintana Roo (Soberanes Fernández 1994). State-sponsored deregulation forced local fisheries to identify new ways to survive in the national and international market.

The Punta Allen cooperative faced one of its worst financial crises in the 1990s. The cooperative had enjoyed a boom in productivity a few years before Hurricane Gilbert struck in 1988 with devastating impact. Several fishers recalled needless and excessive spending of the cooperative's financial resources in the mid-1980s. Given resource abundance and a seemingly endless flow of money, people in the community were not concerned about investing their earnings or consolidating family savings. The cooperative's leaders did not worry about money management, and expenses were often much higher than actual income. The cooperative directors decided to build a packing plant in the town of Tulum, 55 km distant, to receive, package and market all products from the fishing cooperatives in the State. The ice factory and baler were built first, followed by the marketing offices.

After the ice factory and baler were completed, bank managers provided the credit for the marketing offices in a single payment. Construction began shortly before Hurricane Gilbert hit the northern coasts of Quintana Roo. Lobster extraction plummeted. Debts became unsustainable, and cooperative members learned about the financial situation of the cooperative the hard way. Before the 1988 financial disaster, the accountant and directors had kept the cooperative's finances secret. Given this situation, no one wanted to take charge of the bankrupt cooperative, and the responsibility fell to the cooperative's president. The cooperative's debt far exceeded its productive capacity, and many members left the community. Others, in despair over their low incomes, sold lobsters outside of the cooperative. This clandestine selling became such a problem that it seriously threatened the cooperative's continued existence (for a related example, see McCandless and Emery 2008).

The Board of Directors began to crack down on violators, initiating a wave of expulsions of all members who violated the internal rules. The membership rolls shrank from approximately 120 to 70. In 1993, 5 years after Hurricane Gilbert, the cooperative managed to pay off their debt to Ocean Garden, as well as to the Bank of Mexico. The cooperative also decided not to accept new members, including former cooperative members who had left the cooperative during the crisis. The children of former members also lost the right to aspire to membership. After the debt crisis, only the children of current, active members could become members, thereby effectively limiting resource access to a subset of the community. Rights to lobster fields could only be sold to members of the cooperative, and the cooperative regulated all transactions. The selling of a "lobster field" did not refer to the marine parcel itself, but only to the improvements: the "shades" the previous rights-holder had constructed. The cooperative re-emerged as a result of the restructuring of the internal rules of operation. The reorganization had implications for the way fishery resource property rights were protected, which subsequently permitted the cooperative to comply with the requirements to obtain a fishing concession.

Changes in focus and fishing gear

In the 1950s, 1960s and 1970s, area residents harvested, turtle, shark and caiman, as well as scaly fish. Although these were not primary economic activities, they represented a significant portion of the revenues generated during the off-season for lobster. However, shortly after the Sian Ka'an reserve was gazetted, government efforts shifted, following international trends set at the 1992 Earth Summit in Rio. The new policies focused on the diversification of productive activities to lessen the impact of extractive practices on area ecosystems. The government's intention was to put an end to fishing as a primary commercial activity, and replace extractive practices with environmentally friendly activities. As part of this policy, during the 1990s, the National Commission of Natural Protected Areas (CONANP) engaged in an ongoing campaign to convince fishers to stop fishing for turtle and caiman and abandon their fishing nets.

The perceived panacea for unsustainable resource use was tourism. The government promoted tourist cooperatives running sightseeing tours, and some of the fishers created the first tourist cooperatives in Punta Allen and Vigía Grande. The Gaytanes and Las Boyas tourist cooperatives followed. More recently, area residents formed the Nativos de la Bahía and the women's Orquídeas de Sian Ka'an cooperatives (though at the time of

writing the latter is not yet operating tours). After a long process of negotiations and exploration into tourist activities, the fishers decided to withdraw the use of fishing nets. The rationale for this change was the nets' negative impacts on the population of high commercial-value sport-fishing species such as ladyfish (*Elops saurus*), snook (*Centropomus spp.*), permit (*Trachinotus falcatus*), and dolphinfish (*Coriphaena hippurus).*

In the 1990s, tourism was already complementing family incomes, but it was not until 2000 that tourism became the most important economic activity in the community of Punta Allen. Some fishers combined fishing and tourism, while other cooperative members simply abandoned fishing. Over time, a series of tourism cooperatives emerged to regulate the area's resources, strengthening the local community's decision-making capacity. Influenced by external buyers, the remaining lobster fishers decided to change their fishing gear, leaving the hook behind and shifting to the *jamo*. The change in fishing gear was a response to the observed increase in commercial value of the undamaged product harvested with the *jamo*.

Academics have also been important actors in this renewed fishery. At the beginning of the 21st century, the cooperative requested support rom some of the universities and research centers working in the region. Using new technologies, a map of all the lobster fields was created. Previously, the local fishers had delimited the boundaries of their lobster fields with buoys or stakes. Their profound knowledge of the marine space allowed them to find the exact locations of their traps; however, they had never been able to visualize the shape of each field or its actual dimensions. Academics taught them how to use global-positioning systems (GPS), allowing the fishers to improve their surveillance systems and resource usage. Researchers systematized the knowledge about lobster population behavior and performed bathymetry[f] that was subsequently incorporated into a database.

> "…Through SISIERRA [a national research program][g], a map was made using GPS, and it was from that point that we learned the shape of our lobster fields… if you were my neighbor along my boundary, I knew you were my neighbor and where you were, but I didn't know about the others; when we did the mapping in 2001, each of us saw. This is something that we had always wanted, that information could be provided to us (by the academics)… so when this young man showed us the GPS, boom! Our eyes opened…the objective was to map, but now we use the GPS to locate the lobster shades…."(Ramiro, founder, member of the Board of Directors, personal interview, March 6, 2013).

Through these collaborations, the fishers continued to expand and formalize their knowledge of their primary resource, and the environment in which lobster fishing takes place. This knowledge gave them greater negotiating power and control relative to other stakeholders involved in territorial management. All of these processes resulted in a very particular way of understanding territory. The fishery's continued advancement within a conservation area, and the establishment of the Biosphere Reserve, add additional layers of regulation on permissible resource use within those boundaries. The capacity of the Reserve to formally grant and preclude access came to establish a kind of invisible lock that protected the local cooperative and their property rights over the fishery resources, whilst excluding others.

The fishing concession as avenue to cementing success

As mentioned earlier, the Fisheries Act of 1999 recognized two types of usage rights for fishery resources: permits and concessions (DOF 1999). That the Punta Allen cooperative obtained the latter is key to understanding their success and re-emergence. The radical difference between permits and concessions lies in the temporality of rights and forms of access. Under the Fisheries Act, concessions are granted based on an evaluation of the results of technical and economic studies, as well as the amount and predicted recovery time of the investment. It can be granted for up to 50 years. Concessions give rights over benthic resources (such as lobster) in defined geographic areas (Ramírez Félix and Manzo Monroy 2004). Permits are granted for smaller investments and do not require technical and economic studies. For permits, only the nature of the activities is evaluated, and the ownership of the required fishing gear and vessels must be demonstrated (1999 Fisheries Act regulations). While concessions, as a type of right-to-use, are regulated under Mexican law, their application is not an everyday practice in Mexican fisheries, because this kind of access right is not easy to obtain. Though policy at the federal level showed a trend towards deregulation of resources and the inclusion of private capital in extractive practices, in 1993 the fishery cooperative in the Punta Allen community obtained an exclusive 20-year concession for lobster fishing in the Bay of Ascension. This achievement is a significant example of the Punta Allen community's success—most fishing cooperatives in Mexico are not sufficiently well-organized or economically strong enough to obtain such a concession.

The Vigía Chico cooperative received this concession because of their internal organization and marketing capacity, as well as the support of various non-governmental and academic organizations. The cooperative's receipt of this concession is highly significant. The cooperative can then confer rights, also known as concessions, on its authorized users. They provide local fishers with tenured security over their resources and the opportunity to develop future strategies to continue fishing in the area. Those rights, though, are not guaranteed, and must be actively husbanded.

> "…There is a lot of private initiative behind these concessions, so even if you've had it, it could happen. Although I have lived here for years, I will go into tourism, but if I lost my concession…it could happen even if I have the concession that I could lose it, if I didn't care for it; it has a lifespan, it expires…it's not as simple as I want it and it is given to me. You have to fulfill certain requirements…but there are interested parties…the director [of the Reserve] already mentioned to us that there are people after them [for the concession]… then anything we fail to do…" (Ramiro, founder, member of the Board of Directors, personal interview, April 13, 2013).

The cooperative's concession allows local fishers to use this renewable rights-granting mechanism to reinforce their systems of resource policing, and exert ongoing pressure on State authorities to support them in this process. The concession also gives local stakeholders the mechanism to obtain greater control over the organization of extractive practices, via participation in the defense of national sovereignty occurring within their local territory.

> "…We cannot detain a person because we are civilians, so when we go about our operation, we bring the military, as clearly we are civilians… [The military] are

> entitled to detain you; we cannot put anyone in jail and much less detain them, like, say, a pirate.... We operate by boat, dragging and towing the boat, and bring them up here…with the Marines…. Since we go out on operations, we have to assemble three elements. We are going to go prepared, because we can't go find them [pirates] and then later bring the Marines; [it has to be] all at once, three marines or four to set out…" (Rodrigo, founder, member of the Board of Directors, personal interview, April 20, 2013).

The maritime space of the Bay of Ascension, granted in concession as a common property to a productive social organization, effectively becomes the locus of interaction between various stakeholders. Tourism cooperatives, fishing cooperatives, non-governmental organizations, state agencies and entities and academia have negotiated a shared understanding of the resource—and the space it occupies—resulting in sustainable management practices.

Throughout the process of settlement, the Punta Allen community developed an awareness of the importance of adhering to state policies in order to pursue their livelihood activities. The cooperative creatively introduced and adapted these policy prescriptions into their local system of rules. Specially, three significant strategies were developed. First, the cooperative was not only designed and perceived as an organization focused on the productive aspects of fisheries, but also as the primary social institution in the community. Second, cooperative members recognized the Sian Ka'an Biosphere Reserve as an effective organizing structure to support their exclusive management of the marine space. Finally, fishing concessions were effectively deployed as a strategy to control extractive resources access.

Conclusions

To fully understand the success of the Punta Allen lobster fishery we carefully reviewed the settlement history of the community, which yielded a particular social structure. Today, we can trace the positive impacts of forms of spatial and institutional organization linked to particular lobster fishing strategies. These forms of organization have shaped the life of Punta Allen, and now extend beyond the fishery to influence other economic sectors. In Punta Allen, the cooperative, in tandem with the community, has developed a robust, well-tended and strictly enforced system of rights. Through them, the cooperative and community ensure sustainable resource use: they have fostered tourism as an important new dominant economic activity, while still profiting from lobster extraction. We identified several factors enabling this particular set of socio-environmental relationships.

One of these factors was the isolated conditions incomers had to confront during the early days of settlement. Difficulties in marketing the fishing catch, which was necessary to purchase goods needed for survival, forced the villagers to address community issues collectively. The strong community bonds motivated the three leaders, who originally departed from a top-down decision-making approach, to find ways to integrate the existing knowledge and worldviews of community members into collective forms of action. These initial leaders' capacity and willingness to be advised on the legal mechanisms to exercise the rights and obligations as a cooperative also proved critical. Understanding the inner workings of these legal mechanisms allowed the community to effectively integrate federal laws and regulations into local policy and practice. This

bridging between governmental laws and local rules gave symbolic and legal authority to the community's modes of social organization, thereby strengthening locally established systems of sanctions and community rights, as in the Maine lobster fisheries case analyzed by Acheson and Brewer (2003). Cooperative working relationships with regional representatives of various state institutions and NGOs also advanced the community and cooperative's legitimacy in the eyes of government officials.

The ongoing presence and interest of academics in the community has helped to legitimize the state's strategy of enforcing conservation measures while allowing extractive activities. It has simultaneously positioned academics as mediators between the state and local actors. For example, at the time of writing, local fishers and academics are working together to generate a resource inventory, to enable reliable monitoring of natural resources and generate valid indicators for sustainable resource use. This resource inventory will provide the basis for greater scientific management capacity, further legitimating the cooperative's activities and establishing a better position for negotiations with other involved stakeholders. Their position may come to resemble that of the concessionaires of Central Baja California, Mexico (see Orensanz et al. 2013; McCay et al. 2014). At the same time, the group's locally and academically coproduced knowledge of the characteristics of the resource and the institutions involved in its regulation makes users aware of which practices might affect both the resource and the group's existence over the long term. This helps the community keep its informed interests at the forefront of negotiations with government agencies and buyers.

Market influence fostering changes in fishing technique and equipment have also repeatedly influenced the fishery, increasing the value of the spiny lobster as a product and improving fishers' income. More recently, changes in gear have reduced impacts on the area's marine ecosystem. Furthermore, the biogeographic conditions of the bay imposed challenges on inhabitants, forcing them to increase their degree of cooperation and improving their capacity to respond to perturbations, such as hurricanes. This gave the community the ability to understand the significance of cooperation for achieving goals. The ecological and economic perturbation following the aftermath of Hurricane Gilbert offered a window into the potential socioeconomic consequences of a livelihood scenario without fishing. That crisis also forced cooperative members to rethink the system of rules that allow or prohibit group membership and to strengthen its system of internal rules.

The success of this particular community is influenced by a complex of socioenvironmental factors not shared by all artisanal fishing communities globally. Even given its particularity, an analysis of the historical foundations of this particular case allows us to identify indicators worth taking into account in fisheries management more broadly. Punta Allen's Vigía Chico Cooperative increasingly serves as a model for other fishing cooperatives, as well as for NGOs and government bodies. These visitors are gradually developing efforts to reproduce elsewhere some of the mechanisms that have maintained the strength of the Punta Allen cooperative over more than three decades. We hope that our detailed analysis contributes to these efforts.

Today, fishing in Mexico presents many challenges. Fishing permits, when granted, apply to the entire Mexican coast. Government monitoring efforts are inadequate. The result is an institutional apparatus that has been unable to meet the challenges of fisheries management. However, despite the policy of deregulation, the undoing of legislation

privileging the cooperative model, the requirements of formal conservation, and the pressure exerted by private initiatives to access high-commercial-value resources, the Punta Allen cooperative persists. Its continued success offers a clear example of how locally generated, tended and enforced rules can be legitimated and strengthened by strategic engagement with State regulations and regulators. Together with the support of ongoing innovation and collaboration with outside experts, these practices can support successful management.

The Punta Allen cooperative has managed to engage with available governance mechanisms and technologies and collectively fit them to their local context. Their adaptability and tenacity has permitted them to successfully negotiate the shifting terrain of a succession of state actors, policies, and priorities, as well as market and environmental shifts. Equally important has been how the different stakeholders interact in a territory of economic, ecological and strategic importance at the regional and national level.

This case, and other studies of successful artisanal fisheries reviewed here, show the multiple benefits that accrue when different stakeholders work tenaciously to reconcile their interests. Through direct negotiations, legitimacy derived from adherence to regulatory standards and scientific management, processes of exclusion, and skillful engagement of different parties in the performance of everyday practices, Punta Allen's success attests that well-organized local groups can secure viable fisheries and coastal livelihoods.

Endnotes

[a]The shelters or shades are made with concrete and represent an artificial refuge for lobsters. This fishing gear allows the selective capture of live lobster, decreasing damage to juveniles and egg-bearing females, which are returned to the sea during fishing season (Seijo 1993).

[b]The *jamo* is a net that is used to collect lobsters without injuring them. It resembles a butterfly net, but is woven from very strong fishing line.

[c]The time during which this president held office was called *Cardenismo*, and was characterized by its policy of support for the working class, land distribution, the promotion of the cooperative movement and the nationalization of property (see León and Marván 1999; Semo 1993).

[d]"*Parcela,*" or parcel, is a term that farmers use to designate their agricultural plots.

[e]In 1983, during the presidential tenure of Miguel de la Madrid, the "Program of Exploration and Assessment of Fisheries Resources of the Exclusive Economic Zone and the Territorial Waters" was initiated with the participation of the Secretary of the Navy, the National Council of Science and Technology, the National Cooperative Conference of the Mexican Republic, the National Chamber of the Fishing Industry, the state-owned company Mexican Fishery Products, the National Autonomous University of Mexico and the National Polytechnic and other universities in the province. Its purpose was to estimate fishery resources for allocation (Soberanes Fernández 1994).

[f]Bathymetry is the study of the relief of the seabed and its depth contours.

[g]SISIERRA (Sistema de Investigación Justo Sierra) was the name of a research program founded by CONACYT, the National Council of Science and Technology (2001).

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
CMM and BS designed the research; CMM performed the research; CMM and BS drafted the manuscript; SRM improved and added to the text. All authors read and approved the final manuscript.

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"*Paiche* reigns!" species introduction and indigenous fisheries in the Bolivian Amazon

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Abstract

Species introduction, combined with changing access rules, increasing demand, and new road and dam infrastructure, are contributing to remarkable changes in Bolivian Amazon fisheries. This paper examines community responses to the appearance of a commercially valuable introduced fish species, *Arapaima cf. gigas* ("*paiche*") in the Bolivian Amazon. Until the end of the 20th century, fisheries in this region were relatively low intensity, focused in rivers on a small number of native large-sized species by an urban-based commercial fishing fleet, and in floodplain lakes on a high diversity of native medium-sized species for subsistence by rural indigenous communities. In the seventies, *Arapaima* cf. *gigas* was introduced from Peru and has since invaded a significant portion of the Madre de Dios and Beni basins in northern Bolivia. This species now represents up to 80 % of commercial catches for the region. Occupying primarily floodplain lakes, many of which are located within indigenous territories, it has created economic opportunities and stimulated conflicts. The evolution of fisheries in one indigenous Tacana community is described, and the perspectives of local fishers are explored. Results suggest that while the new resource has strengthened incipient community-level organization, the current capture strategies and management mechanisms may not be conducive to sustainability or equitable distribution of returns. Commercial fisheries targeting a set of native species have been replaced by a single-species fishery in this community, raising questions about how the changes both in the resource-base and associated livelihood strategies are impacting system resilience. Ecosystem impacts of the introduction remain unclear. *Paiche* is viewed both as a potential threat and an opportunity by indigenous fishers. The management of this introduced species for a maximum social benefit and minimal environmental damage are topical concerns for communities and government actors and should be treated carefully considering local and broader, regional-scale implications.

Keywords: Artisanal fisheries; Bolivian Amazon; Introduced species; *Arapaima* cf.*gigas*; Adaptation; Resilience

Main text

Introduction

Globally, fisheries are increasingly vulnerable to a multitude of threats, resulting in an interest in fostering adaptation among fishing peoples (FAO 2007; Daw et al. 2009). Introduced species are considered one of the prime factors that contribute to the decline of native species and significant negative impacts on fishery-related livelihoods globally (Clavero and García-Berthou 2005; Shackleton et al. 2007). However, where communities have been able

to make use of non-native aquatic species, these can sometimes also present a new, economically valuable resource, as is the case of a variety of introduced fish species in the reservoirs and rivers of south-central Brazil (Hoeinghaus et al. 2009), and the Nile perch in Lake Victoria (Mkumbo and Marshall 2015). The Nile perch, in particular, has supported remarkable economic development in central African lakes after its introduction in the late 1970s (Mkumbo and Marshall 2015), though its negative environmental impacts and inequitable social benefits have long been criticized (see for example Von Kaufmann 2007; Balirwa et al. 2003). This paper presents a case where introduced species are providing economic opportunity, and explores adaptation strategies and resilience capacity by local fishers.

Resilience and adaptation are key concepts in understanding and addressing the challenges that introduced species present to small-scale fisheries. The resilience concept (Holling 1973) describes a cycle whereby ecosystems, human systems (communities) and management systems absorb unexpected shocks and perturbations without collapsing or otherwise entering an intrinsically undesirable state (Berkes and Folke 1998). In other words, resilience is the capacity of a whole system to respond to disturbance and shocks, while maintaining essential functions (Walker et al. 2004; Folke et al. 2005; Folke 2006). In a fishery, resilience is pertinent for management institutions, fishing communities, value chain, and the ecosystem in which the fish live (Charles 2005). There is a growing interest in enhancing the resilience in fisheries (Allison et al. 2007). In this context, adaptation is based primarily on groups managing the fisheries resource system by intentionally or unintentionally moving thresholds within the system (Walker et al. 2004). In the case of species introduction, adaptation in fisheries includes not only thresholds related to the relationship between resource users and resources in an existing and potentially 'knowable' system, but also new interactions and thresholds with unpredictable outcomes resulting from the external driver. It is important to consider the wide consequences of disturbances and adaptation to external drivers on fisher well-being and to better understand how these strategies are implemented and feed back into the resilience of fisheries as a social-ecological system (Coulthard 2012); these elements are critical to informing effective resource management planning.

Arapaima cf. *gigas* (*paiche* in the study area; *pirarucú* in Brazil; hereafter referred to as *paiche* in the text), the world`s largest scaled freshwater fish, is native to the middle and lower portions of the Amazon Basin, where it has been largely overfished, but is not native to the Bolivian Amazon. *Paiche* was introduced to the upper Amazon headwaters of Peru in the 1960s (Carvajal-Vallejos et al. 2011), and first appeared in the Bolivian fisheries approximately 20 years ago. Currently it dominates the commercial catch in the northern Amazon region of Bolivia overall (Coca Méndez et al. 2012). Knowledge to date on the biological and ecological impacts of *paiche* introduction is presented in Miranda-Chumacero et al. (2013). The contributions of *paiche* to indigenous fisheries varies significantly at the local, or community level, and is likely influenced by a number of factors including access to floodplain lakes where *paiche* is present and abundant, adequate technology (gear and knowledge), connectivity to markets, and the mix of livelihood activities. Overall, high species diversity continues to be a key feature, both for subsistence and more recent commercial fishing in indigenous communities in the region surrounding Trinidacito. In a recent study by Argote et al. (2014), a total of 67 species were recorded in the fisheries catch for seven indigenous communities (including the study community of Trinidacito) over a one-month period. Native species landings were dominated by Characiformes,

Siluriformes, and Perciformes, with medium-sized catfish and piranhas of particular importance. It is not yet known if, or how, *paiche* affects the native fish communities in the region.

The *paiche* invasion is occurring in the context of a rapidly changing social environment of land reforms, increasing urban and rural populations and expanding road access in Bolivia's northern Amazon region. These intersect with an increasing indigenous ownership, political decentralization, and a largely undocumented and unmanaged fishery. This complex context circumscribes the potential adaptation strategies and capacity for resilience displayed among fishing communities in the region. Indigenous groups have traditional access rights to natural resources, recently recognized by the national government, and a vested interest in their sustainable use. However, they face significant challenges in developing and implementing resource management strategies, including low technical and financial capacity and weak monitoring capacity. A better understanding of the range of social and biological impacts of the paiche introduction, and of local priorities and underlying values concerning aquatic resource exploitation and conservation, could provide useful insights as to how local fisheries have adapted to change, and inform appropriate development strategies.

This study presents some local views about the social and ecological impacts of *paiche*, and its role in fishery development of one community, including perspectives from some of the most successful *paiche* fishers in the region thus far. In explores how people in an indigenous community perceive and act in response to an external driver, in the context of changing governance frameworks at different scales, and identifies the factors which contribute to adaptation and resilience in the local fisheries system.

Methods

Study area

The northern portion of the Bolivian Amazon is an area of about 100,000 km^2, and includes the departments of Pando, Beni (Vaca Diez province) and a portion of La Paz (Iturralde province). An estimated three-quarters of this is upland tropical forest (Ibisch et al. 2003), but over 16 eco-regions are reported (Paramo 2005). The rivers, headwaters of the Amazon Basin, are home to a high diversity of fish species (Carvajal-Vallejos et al. 2014), and are considered of high ecological significance (Ibisch et al. 2003).

Indigenous communities in the Bolivian Amazon are largely organized in Communal Territories of Indigenous People (locally "Tierras de Comunidades de Origen" or TCOs), mostly located in forested areas, often close to rivers or lakes, with limited access to regional urban centres by unimproved roads or fluvial transport. In the region, these territories cover over 6921 km^2, with an estimated total population of 69,000 (Soria 2011). Livelihoods and subsistence are based on small-scale agriculture, fishing, hunting, and gathering of forest products, according to local availability of resources.

The study was carried out in the TCO known as "Multi-ethnic Indigenous Territory II " (hereafter referred to as TCO TIM II), located between the Madre de Dios and Beni rivers close to their confluence (67°0′0″, 66°0′0″ W, 11°30′0″, 11°0′0″), and overlapping partly with both the Beni and Pando Departments (Fig. 1). The rivers approximate the borders of the TCO TIM II, and are used extensively for transport and fishing (by urban-based commercial fishers). Road access in the region was very limited, with improvements starting in 2007, and recurring interruptions due to seasonal rains and

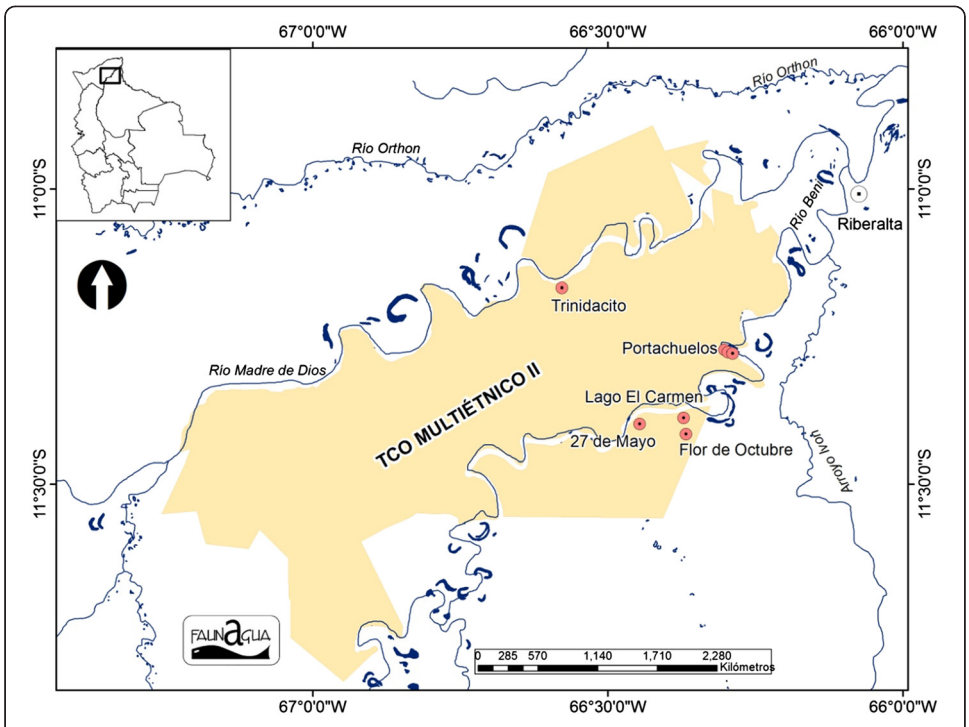

Fig. 1 Multi-ethnic Territory II (Territorio Indígena Multiétnico II - TIM II), situated between the Madre de Dios and Beni Rivers in the Departments of Beni and Pando, Northern Bolivia. Trinidacito and several other communities in the TCO TIM II, located in Madre de Dios and Beni watersheds are shown

floods. This area forms an extensive lowland floodplain system, at altitudes less than 300 m above sea level, intersected by numerous oxbow lakes (a shallow lake formed in a meander cut off by the drift of the main river in the floodplain) and with a pluviseasonal tropical climate whose dry season extends from May to September (Navarro and Maldonado 2005).

TCO TIM II is comprised of communities belonging to three distinct indigenous groups (Esse Ejja, Tacana, Cavineño). This study focuses on the Tacana community of Trinidacito, located close to the banks of the Madre de Dios River, in an upland location (Fig. 1). Trinidacito is notable for its productive and locally managed commercial *paiche* fishery. The nearest urban centre is Riberalta, a regional river port city at the confluence of the Madre de Dios and Beni Rivers. This is the location of regional fish markets and exporters to national and international markets, and at the same time is the national centre for processing and export of wild-harvested Brazil nuts (*Bertholletia excelsa*) - the main contributor to the regional economy.

Surveys

Information was collected from published sources and reports on the general history of indigenous groups and fishing activity in the region. This was complemented by detailed interviews with people locally identified in Trinidacito as the oldest or most knowledgeable with respect to community and fishing history. Interviewees were selected by a combination of purposeful sampling of community and fishing leaders (direct observation), and an exponential, non-discriminative snowball method (Berg 1988); respondents were asked the question, "who are the most active and experienced fishers

in the community?" A total of 16 men and one woman were interviewed between August 2011 and June 2013. In many cases, fishers' wives also participated in and contributed to the interviews. Data were transcribed and organized using NVivo 10 software, according to key themes, historic timelines, consensus regarding events and perspectives, etc. Drawing on methods from human ecology, an adapted process of progressive contextualization (Vayda 1983) was used in the analysis of interview data to organize the story of fisheries participation, *paiche* introduction and the local responses. Findings were compared with data available from comparable studies in other parts of the Amazon Basin.

Results

Historical perspective

Rights to natural resources were historically concentrated in large rubber-tapping estates known as *barracas*, held by a very small group of elites (Garland and Silva-Santiesteban 2004; Pacheco 2003). Following the Second World War, the *barracas* underwent reorganization towards other extractive activities, notably Brazil nut harvesting (Cardona 2012). Beginning in the 1990s, decentralization of government, re-assignment of land rights, and establishment of indigenous territories (Indigenous Community Territories - TCOs) all contributed to the development of modern indigenous settlement and livelihoods in the region. Current fisheries result from the combination of both historically practiced traditional subsistence activity and new commercial opportunities.

The recognition of communal rights for exclusive access and traditional use of natural renewable resources located within the TCO territories was included in the national land reform of 1996 (Garland and Silva-Santiesteban 2004). However, the rules defining and permitting commercial activity and individual extractive activity within this framework are not clear. Specific regulations on natural resource exploitation and sustainable management at the level of the TCOs continue to evolve, including for fisheries, as their commercial potential is increasingly recognized. A new national fisheries law proposal, which involved a high level of consultation with fishers in its development, is currently pending approval and will provide additional clarity on resource access rules.

There is very little documentation for commercial fisheries in northern Bolivia prior to the 1980s, but fishing activity likely began to increase during the slow end (1970s–1990s) of the rubber industry (Cardona 2012). At this time, a variety of communities (indigenous and campesino) living on *barracas* abandoned them to create new settlements and pursue previously disallowed independent agro-extractive livelihoods (Henkemans 2001). More communities were located in proximity to urban centres and people increasingly participated in the regional market economy (Pacheco 2003). The remaining *barraca* estates continued to dominate the landscape, mainly through the Brazil-nut industry, and controlled access to fisheries in many of the lakes and smaller streams until well into the 1990s (Cardona 2012). Between 1980 to mid-1990s, the focus of commercial fisheries in the region was the larger-bodied catfish and other high-value fish in the main rivers, carried out mostly by small to medium sized boats (Van Damme et al. 2011). The floodplain lakes were used by local communities for subsistence, while commercial fishing was carried out by urban-based boats, as they travelled along the main rivers and fished opportunistically in accessible lakes to supplement their catch from the river. These boats also

purchased fish from the communities or traded in exchange for supplies. A new network of river traders emerged as the *barracas* system of community supply stores declined and road access continued to be very limited (Henkemans 2001). These new changes likely contributed to the formation of *habilito* relationships in the community-based fisheries, in which intermediaries provide credit for operational costs of harvesting in return for exclusive right to market the fish catch. This continues as a dominant factor in most of the commercial fisheries in the region.

In general, the participation of indigenous fishers in commercial activity in this region was relatively limited in terms of overall production volume, increasing rapidly only in the past 10 years. Prior to the emergence of the *paiche* fishery, commercial fisheries in the region focused on the exploitation of a handful of large-sized species in rivers and lakes such as *Colossoma macropomum* (local name *pacú*), *Pseudoplatystoma* spp. (local name *surubí*) and *Zungaro zungaro* (local name *chanana*) (Van Damme et al. 2011).

Arapaima cf. gigas (paiche), a new resource

The regional fisheries picture changed dramatically from the 1990s onward, due in large part to new fisheries based on the introduced *paiche*, currently making up over 60 % of total landings (by weight) for the Riberalta region, 40 % of indigenous commercial landings in the region (Coca Méndez et al. 2012), and 82 % of landings in Trinidacito (Argote et al. 2014). *Paiche* may also represent a number of new threats to the native fish resources (Van Damme et al. 2014).

Until very recently, *paiche* meat was sold in the national urban fish markets only as fillets of *surubí* catfish; while texture, taste and appearance of the two fish are distinct, consumers are not well-informed and do not usually discriminate between these species (Van Damme, personal observation). For the past three years, it has begun to appear in upscale restaurants and is now sold in some fish markets as *paiche*. While the main markets are regional urban centres in Bolivia (La Paz, Santa Cruz, Riberalta, Cobija) significant amounts of *paiche* are also sold fresh or salted to intermediaries who export it illegally across the border from Guayaramerín to Brazilian markets (Coca Méndez et al. 2012) where it is highly valued.

Local actor perspectives in Trinidacito

Trinidacito is a Tacana community, established in the early 20th century as a *barraca* for rubber extraction. It was governed by a local boss who lived in the community. A variety of *caciques* (local people appointed to leadership and regulatory roles) directed and financed fisheries activities until the community became involved with the indigenous movement around the time of the regional indigenous census in the early 1990s. The community was included in the creation of the TCO TIM II, following the Instituto Nacional de Reforma Agragia (INRA) law in 1996. The community is approximately 90 years old, among the oldest modern settlements in Pando Department, with 350 residents from 73 families. The main livelihood activities include seasonal harvest of Brazil nuts (January–March), fishing, agriculture and occasional participation in gold mining activity on the Madre de Dios River (Ledezma, unpublished data 2011). The community has one health post, one school, and unpaved road access to Riberalta (since 2006–7), one cellphone communication tower, recent wells for potable water (2013), and several gas-powered generators that are used sporadically.

Compared to other communities in the study region, Trinidacito has a relatively long history of local participation in commercial fishing activity. According to interviews, the formation of the oxbow lake Lago Mentiroso, currently the main fishing location for the community (Argote et al. 2014) and one of the most productive lakes in the region (Carvajal-Vallejos, unpublished data), was accelerated with the help of human modification (channel-cutting) by crew from one of these commercial boats around 1925. Consequently, it continues to have relatively high connectivity to the main stem of the river, facilitating entry of boats and, as a result, emergence of conflicts. Participation in commercial fishing activity is reported to have begun approximately 50 years ago, with a low level of organization and uncontrolled access by outsiders. For two decades (1960–70s) there was sporadic, uncontrolled entry into local lakes for commercial fishing by fishers from Riberalta and nearby communities. At this time, the lake fishery was based on the native species, mostly *pacú* and *pacupeba* (*Mylossoma* spp.), and fish were sold to medium-sized commercial boats (two person crew, and holding capacity of up to 10 tonnes) that were frequently travelling on the Madre de Dios River, carrying supplies and product to and from the *barracas*, occasionally fishing in the river and lakes, or trading goods for fish from local residents. Several of the older fishers describe fishing in cooperation with urban-based partners or investors during this time. Hook and line was the gear most frequently used, those who could afford them also used gill nets (500–1000 m in length). Interviewees reported very high abundance of fish during this period (for example, catches of 90–100 pacú (8–10 kg size) per 300 m of gill net). Less commercially desirable fish, such as *corvina* (*Plagioscion squamosissimus*) for example, were used locally for subsistence or discarded as by-catch (to "not waste salt"). The price at this time was very low, at Bs. 2 per kg of salt-dried fish (roughly equivalent to US $0.10).

At the same time as the regional population grew, the demand for fish increased, rubber-tapping activities declined, local interest in commercial fishing grew, and conflicts arose among rural indigenous and urban-based fishers. In the 1980s, triggered by destructive fishing practices of outside parties, the community organized into an association and lobbied successfully for exclusive access to the lagoon in exchange for a concession fee paid to the regional government, which initiated community management. Concession fees were commonly used in the region in the 1980s and 1990s for licenses to exploit different forest-based products, including rubber, Brazil nuts, hardwoods, etc. Interviewees describe a significant effort over time to organize and protect resource access rights. The founding president of the fishing union reports that a concession of Bs. 700 (between US $16.00 and US $35.00 at the time) was collected from the fishers' annual royalties and paid to the National Centre for Fisheries Development (CDP) for five years, from 1980–1984. A later president states that a concession of Bs. 1000 per year (approximately US $ 294.00 at the time) was also paid to the municipality for a period of two years in the early 1990s, around the time that interest in fishing the *paiche* began to develop. With the exclusive rights guaranteed through this concession, the community was able to legally control the incursion of outside fishers by confiscating their gear and imposing fines. One male fisher comments,

> "Those outsiders, those fishermen, how do you call them, the 'professionals' from Riberalta, were always coming in and plundering us…Problems arrived to them with

all of this. They were fined and all of those things…we would confront them and take all the material they had. To get it back, they had to pay us a fine."

Paiche appeared around Trinidacito sometime in the late 1980s (reportedly seen in Lago Mentiroso as early as 1984) but was not commercially exploited until at least 1990 when a small group of outside fishers (possibly from Brazil) were observed catching and transporting the *paiche* fresh on ice. Within a few years (1992), a group of three local male fishers began catching *paiche* and selling it salt-dried to two buyers from Riberalta, for Bs. 2.50–3 per kg (US $ 0.67–US $ 0.81 at the time). Other buyers on the Brazilian border (Guayaramerín) subsequently began paying Bs. 5 per kg (US $ 1.35 at the time). At this time, *paiche* was in high demand and extremely over-exploited in Brazil.

Likely triggered by this demand and responding to a new national legislation for regularizing associations, the local fishing association was registered in 1994 as a working union, with 14 original members. This union grew to more than 40 active members, described as very well organized and effective at regulating the activity, collecting fees and distributing permits. An unprecedented increase in *paiche* fishing and an accompanying decline in the abundance of native species were observed. *Paiche* production peaked for several years; one younger male fisher who arrived in 2001 comments that at this time there were many more *paiche* in the lake, and more people in the fishery (as high as 60 active members).

In the early 2000s, some regulation of commercial fisheries at the Department level occurred, following a similar model to that established by the CDP in the 1990s, and including an agreement for permanent exclusive use of the lake. This is documented in the written records of the fishing union (2004–2009) (Herrera et al. unpublished observations), and included a requirement for an expedition permit (*faena*), valid for 30-day periods. Additionally, fishers paid a royalty, based on the total catch volume, (approx. 10 % of the sale value, or 0.20 Bs./k (US $ 0.05 at the time)). Similar to the earlier arrangement with the CDP, registration and fee collection for permits and royalties was carried out by a locally appointed monitor for the union who received a percentage of the royalties as a salary, and delivered the rest to the departmental office, located in Riberalta. This system was seen as effective and positive by many fishers interviewed. According to one male fisher,

"In the past there were norms…one had to have a license, permission to enter the lake. Because in these licenses it said even in which boat one would be fishing. How many kilos, with what material. These licenses were used for one entry for fishing, nothing more. A permit, as you could call it. If you wanted to go in again, you needed another permit…I authorized people and gave them the papers…and there was another paper where kilos were recorded…"

Overlapping with this time period and jurisdiction, the creation of the TCO TIM II reserve in the 2000s led to a new process of negotiating, whereby agreements for each of its 34 communities were made to guarantee their access to traditional resources and land. Within the framework of TCO regulations, Trinidacito secured exclusive rights to Lago Mentiroso, due to the history of use and existing agreement with Pando Department. Resulting from this, the royalty payment was to be transferred to the local community association (who would pay a portion to the TCO TIM II government) and a third fee, monthly

membership dues for the fishing union (Bs. 10 or US $ 2.70 at that time) was also instituted, though there was a period of confusion regarding the payment of fees, and legitimacy of the different agencies to collect them.

In 2010, the union was re-registered as a productive association, to align with changing TCO regulations and national laws governing productive associations and professional unions. During this time, the fisheries office distributing permits moved significantly further away to the Department capital of Cobija and the collection of permit and royalty fees became more sporadic, with payment of fees becoming highly dependent on local enforcement. At the time of interviews, a recent change in association leadership and doubts about paying the fees to municipal government meant that none of these fees had been paid in at least a year. The framework for resource management is in transition as the TCO government becomes more active in its governance and establishing regulations and resource management provisions. In the meantime, the enforcement officer is no longer active, resulting in an increase in unregulated fishing activity without payment of royalties, a renewed invasion by outside urban-based fishers and an increased call for seasonal closures. The local fishers report dissatisfaction with the current lack of regulation on the fishery:

> "Nowadays people work without any documentation, no permits…Who authorizes the entry in the lake? In the past…the lake itself belonged to the community, but those who were doing the work of the fishery were unionized with all the appropriate documentation …this was done so no one outside the community could come in, so there was work for people from here. So no one pirated. Now…anyone can come in…."

In 2007, road access to the community was improved, enabling faster transport to Riberalta (2 h) and a change in the *habilito* dependence, and fostering independence. Several fishers purchased motorcycles, and began transporting fresh fish directly to Riberalta markets in search of a better price. However, due to the high costs of credit and supplies required for paiche fishing, this also included setting up new networks of *habilito* with Riberalta buyers. Some buyers arrived by car and fishers reported that the main vehicle bought and carried 400 to 450 kg of *paiche* per trip, on average 3 times per week. Local estimates place the total number of *paiche* fished at 70–80 fish weekly (1000–1500 kg/week) during the peak production time of March – April (the beginning of the fishing season, after the Brazil-nut harvest). By 2012, *paiche* was almost exclusively transported to Riberalta by motorcycle and sold fresh, directly to large-scale intermediaries. Women in Riberalta, employed by these intermediaries, process and package the meat into large filets before its shipment by air to national markets.

Currently, the entire commercial fishery in Trinidacito is directed to *paiche*, while other smaller-bodied native species are reported to be fished for family consumption only, as secondary income for food, clothing, etc. "to sustain the family through the year". Brazil nut harvesting continues to be a more profitable economic activity overall, providing the bulk of family income, used for improving housing or purchasing transportation.

According to local fishers, both native species and the *paiche* have decreased in abundance. According to the oldest male fishers in the community, a great deal more effort is now required to catch the native fish. The reduced effectiveness of hook and line has motivated some to use gillnets, including seine nets, which catch fish indiscriminately, one of the causes of "ending with everything." The *pacú* and *surubí* fish are considered

top commercial species in other nearby communities; in Trinidacito these other species are utilized for subsistence and very occasionally for commerce.

> "The *paiche* reigns! I would like only that they close this side [of the lake], locking it up, wrapping it up for two years. So that the countless thousands of kilos of fish will come here again. I haven't fished those thousands of kg anymore. Just me! And we were 40 fishermen. He who fished least, weekly, arrived with 300 kg salt-dried, imagine the decline. He who fished least. It was a fantasy!"

> "Heavily, they have diminished, in the case of the *pacú* at least. Back then, we caught *pacú* without need of gillnets. We'd catch 10-12-15 *pacus* in the day, just with fruit. Now there aren't any. Since the presence of the *paiche*. There are a lot of *paiche*!"

In addition to access issues, the unequal distribution of benefits from the *paiche* fishery is one of the main conflicts. Overall, there is some debate at the community level over what to do with *paiche*, since it is seen as a revenue generator for only a few people, even though it is a communal resource. Some suggest re-establishing payments to the community association and creating more widely beneficial value-added processing activities. The recently amended TCO regulation (2013) now permits commercial fishing activity for a subset of communities through their local associations. Prior to this, only forestry and harvesting of forest products (under community management plans) were permitted. Individual economic opportunities are still not clearly recognized within this framework.

Trinidacito is the only community within the TCO TIM II with established local norms regulating the fishing activity, including specific rules for the exploitation of *paiche*. These include mandatory membership in the commercial fishing union/association, mandatory participation in monthly meetings, reporting of catch data, payment of royalty fees (until recently), and observation of fishery closures. Fisheries closures are determined according to perceived best seasonal periods for *paiche* exploitation, in coordination with other extractive and agricultural activities. Restrictions on gear-type inhibit gillnet use, unless for communal harvests (native species) for social or ceremonial purpose. A system of fines and exclusion set by the community leaders is applied for non-compliance with the regulations. There is some indication of a rule allowing temporary closures when it is perceived that the catch levels are declining. There are no rules or social norms regarding minimum size, or fishing *paiche* during the reproductive phase.

When asked about permitting the use of gillnets in the community (a practice commonly observed, but widely and emphatically prohibited) respondents' opinions were divided. Gillnets are prohibited by both the TCO and community regulations, but over half the fishers were observed to be using them, as evidenced by the fisheries monitoring data.

> "It is prohibitively [sic] prohibited, the use of gillnets. They aren't allowed in the regulation…for the TCO. They are prohibited…everyone knows they are prohibited. Prohibitively! [sic]."

> "No…it scares the fish, and the gillnets destroy everything. Even the cats fall in them! They pull up everything, even the anacondas!"

> "It would be good to allow them to some degree, in a controlled manner, maybe twice a month or something."

The reasons for not using gillnets include "fish learning to avoid capture" or being scared off, rather than potential over-exploitation. The clandestine use of gillnets is a secondary conflict which includes equipment robbery, from within the community and from outsiders, or 'borrowing' and leaving material somewhere else. Several fishers report having *paiche* gillnets stolen from their hidden storage locations close to the lake.

Other fishers commented on insufficient legislation or higher-level norms governing the fisheries activity, but reiterated the importance of local regulation and rules at the community level.

> "Nowadays we don't have norms, as you'd call them…there is no legislation… people are like this, some want them, others are not interested…. But we have [local] rules of course. For example, one has to obey the rules. One has to accept to be organized, to be an associate in order to fish. If there is a monthly membership fee, to pay it. One has to have permission…. One has to be affiliated and in good standing and accept all the conditions that are put in place by the internal rules… [The rules were made when] it was observed that rules were missing. But even rules don't necessarily mean 'responsibility', as many people know, for example these fishermen and salt-dryers who catch *corvina* [less commercially important] and throw it away….because they don't want to waste salt on it…"

In Trinidacito, *paiche* has seldom been incorporated in the local diet, although several families reported occasionally eating it as *chicharron* (fried in cubes), or beginning to include parts in soup. One respondent remarked that this resulted from copying 'as we saw the rich ones do'. All interviewees indicated that *paiche* is important for economic activity; many also suggested that since its arrival the abundance of smaller-bodied native species has decreased.

> "Well, the *paiche*, despite being an introduced species in the country of Bolivia, the *paiche* has come to bring us many sources of work to the communities and the fishermen who are also from outside. It is a very profitable source…It's good…We have maintained it for years, by fishing in a sustainable way….with our more traditional materials from here….hooks and lines."

> "For me, *paiche* is good, that's it…because you can even eat it, it's good for selling, everything."

> "For me, it would be much better for there to be *paiche*. It's what sustains, like I said. It never disappears completely, good fish, it can always be fished."

Only two fishers indicated that *paiche* should be reduced or exterminated, to eliminate predation on the native species that are locally important for subsistence. However, these same two respondents are young, full-time professional *paiche* fishers, with limited experience fishing the native species, and could be looking for increased opportunity to fish *paiche*.

Discussion

The introduced *paiche* has significantly impacted local resource and governance systems since its appearance in Bolivia, in particular for the indigenous community of Trinidacito.

This research provides insights into adaptations to introduced species, which we describe as they relate to 3 focus areas: local organization in response to the external driver of *paiche*, its contribution to diversified livelihood strategies and implications for resource sustainability, and the influence of conflicts.

External drivers and local organization

The evolution of the local fishery management system in Trinidacito has had several stages, responding to triggers from external pressures (conflicts with outside fishers and new species), developing within a changing environment of regulatory authority, and grounded in both historical formal relationships and local practice. This corresponds to the release, re-organization and exploitation components of the "Holling cycle" (Walker et al. 2004). The local fishery evolution shows evidence of adaptation as the community self-organized and learned to make use of the new resource. The community is now strongly engaged in commercial fisheries exploitation, based almost exclusively on *paiche*, with some local management, though conservation or sustainability practices for this are less evident than economic ones. However, while signs of over-exploitation of the native *pacú* and *pacupeba* fishery were becoming apparent in Trinidacito in the 1990s, the *paiche* fishery was building, thus avoiding the phases of overt collapse and re-organization that could have been expected of the native fish fishery. The relatively large scale of the *paiche* exploitation and regulatory uncertainty after the collapse of the CDP and the creation of the TCO TIM II, triggered re-organization and a strengthened local union – primarily to secure continued exclusive community access to the resource, and regulate distribution of *paiche* fishing rights. Most recently, the new road access, a shift to fresh fish, and renewed uncertainty of upper level authority have created new value chains and possibly is triggering a new phase of institutional re-organization. Institutional experience at the community level, possibly building on the history and social learning of rigid organization from the rubber era, contributed considerably to the success of formal steps of organization. For example, interviewees in Trinidacito identified the lack of a local regulatory officer as a key factor contributing to deteriorating conditions. Overlapping jurisdictions and unclear authority of different governance actors during the transition to TCO governance also appear to be causes for local concern.

Livelihoods diversification, conservation and sustainability

The *paiche* introduction has provided Trinidacito an opportunity for livelihood diversification (to include a new species and fishery), which can be a resilience-building mechanism (Allison and Ellis 2001; Marschke and Berkes 2006). Indigenous fisheries of the TCO TIM II in the Northern Bolivian Amazon are part of a multi-faceted livelihood that has evolved from a history of subsistence hunting and gathering to include more income-generating, commercial extractive activities including rubber, Brazil nuts, and most recently, fishing. This ability to diversify and adapt to resource availability is an important part of resilience in the face of multiple stressors. Livelihoods continue to be based on seasonal cycles of agriculture and Brazil nut harvest, with fisheries for subsistence and commerce playing an increasingly important role for many communities, though in general considered of a secondary supportive role. In some cases, such as Trinidacito, commercial fisheries have increased because of the availability and profitability of the *paiche* fishery,

but continue to be practised as a seasonal activity, interspersed with Brazil nut harvesting, and still considered a secondary source of income, which may enable more flexibility and ability for small adjustments - for example to lower fishing effort when scarcity becomes apparent. This contrasts significantly with other fishing communities in the same reserve who do not have access to the same mix of livelihood activities as Trinidacito, and have a lower abundance of *paiche* in their lakes. For example, in the more recently settled, flood-vulnerable communities of El Sur (located near the Beni River, TCO TIM II) landings include a diversity of medium-bodied native species and significantly less *paiche*. Most community members are engaged in commercial fishing year-round, with fishing constituting a 'safety-net' to deal with other shocks of life on the floodplain. Fishing as a 'buffer' is an adaptation mechanism, which these communities utilize to increase their resilience to external stressors. This is also consistent with results from the Peruvian Amazon (see Coomes et al. 2010) and the observation of highly heterogeneous fisheries in small communities of the Brazilian Amazon (Castello et al. 2013).

The current Trinidacito model is an interesting example of a single-species commercial fishery, despite high diversity of native species in the region. Currently, there is clear evidence that Trinidacito fishers are targeting *paiche* exclusively for their commercial fishery, with occasional opportunistic capture of other species for subsistence or sometimes for sale. This represents a significant shift in their fishery, and its implications for fishing effort, resource sustainability, or long term resilience are not clear. There is insufficient data available to determine the abundance of the native fish species in the lagoons surrounding Trinidacito and whether this has been affected by the *paiche* or fishing pressure.

Significant changes are evident in biological and social aspects of the fishery, demonstrating social innovation and adaptation, as well as a mismatch between expressed conservation interests and a lack of evidence of accompanying stewardship behaviours. The catch composition in the overall region has shifted considerably; fishing effort in Trinidacito is almost exclusively dedicated to *paiche* harvest. While local knowledge of the autochthonous species and interest in conservation were evident, these were not connected with associated stewardship behaviours to protect threatened stocks. For example, serious reductions of fish stocks of *pacú, pacupeba*, and *paiche* were referred to, though these are not evident from the sparse fishing data. Perception on the cause of these reductions was not clear, though local overfishing is considered a very likely factor. Interviewees also expressed concern about overfishing and waste (such as discarded by-catch for species such as *corvina*), and are asking for more restrictive management, both for sustainability and to reduce waste, but are not necessarily practicing conservation in their fishing methods.

Current fishing practices in Trinidacito are likely unsustainable. Although prohibited by local regulations, non-selective gillnets are widely used. In addition, new fishing gears to catch *paiche* have been developed - for example the *arma blanca* (see Fig. 2) is a particularly destructive strategy for this fish species because it targets individuals that are protecting their offspring, making the young individuals more vulnerable to predators (Castello, McGrath and Beck 2011; see also Imbiriba 1994). Unlike examples from indigenous fisheries of the Brazilian Amazon (e.g. Amaral 2005), traditional methods such as harpoons, arrows, and poisons are largely absent. There were common references in interviews to fish learning to avoid fishing gear, particularly gillnets. While this

Fig. 2 Fishing gear 'arma blanca' invented and used for paiche fishing in Trinidacito, TCO TIM II

argument may be a prelude to the introduction of more efficient gear with the first signs of overfishing, our interviews indicate some evidence that *paiche* will actively avoid areas being fished by gillnets (or other gear). On an annual basis, there is a peak of *paiche* catches at the start of each season, even though the fish being caught are at least several years old and largely resident in the lakes being fished. While the predatory nature of these fishing strategies were marginally mentioned in some interviews, this was often tempered by the perception of abundance of this fish and the identification of it as something introduced, or not belonging, and possibly threatening the native stocks, despite it now forming the basis for the entire fishery. Management mechanisms such as minimum size restrictions, and seasonal closures for fish reproductive periods, cited in other areas as critical elements supporting *paiche* recruitment and abundance (Castello 2004), are not yet used or considered in this region for *paiche*. This may be due to a lack of clarity surrounding whether sustaining introduced populations should be a goal as there currently is no overall local perception of resource scarcity, and local knowledge of best conservation practices for this species may be limited. This may change if the local *paiche* resource does become substantially reduced.

Conflicts

Trinidacito is one of earliest indigenous communities to develop a commercial fishery in the region, initially responding to a strong market for native fish, facilitated by its proximity to the Madre de Dios river, the proximate location of a large, deep, productive floodplain lake (Lago Mentiroso), and increasing connectivity with regional markets in Riberalta. User conflicts have been exacerbated by the presence of this highly valued resource within indigenous territories; the unequal distribution of benefits from fisheries is an ongoing concern for all of the fisheries in the region. This included conflicts with outside fishers that triggered early self-organization and a lobby by the community to department-level authorities to gain exclusive community access to the resource. Two main persistent conflicts referred to in the interviews were those between local and outside fishers, and the relationship between the fishers and intermediaries (*habilito*).

The first of these, conflict over access, has triggered stronger levels of community organization that undoubtedly helped the development of the community overall, highlighting the potential positive spin-offs of conflict as a stimulus for change and improved resilience. Similar conflicts in other communities in the TCO TIM II did not appear to be so dramatic, and did not trigger similar levels of community organization.

The second source of conflict, *habilito,* a social contract in fisheries where credit is provided to fishers in exchange for exclusive right to the fish catch, is a dominant factor in most of the commercial fisheries in the region. This relationship is generally not favourable for the fishers, and is based on a long history of similar arrangements for extractive workers in this area for rubber, Brazil nut, and mining activities. In general, *habilito* enables a relative monopoly of some aspect of the value chain by the intermediary, for example transport, ice, or market access. To some extent, this element was challenged in Trinidacito with new road access and the profitability of *paiche*, which allowed fishers to transport their catch to urban markets directly by motorcycle and to experiment with the establishment of a local processing plant in the community. It remains to be seen if the new value chain links created through these changes are better than the earlier *habilito* system, or if new *habilito* arrangements will be created.

Conclusion

Introduced species may represent both new opportunities and challenges to fishing communities that influence their well-being and resilience. For example, the introduced Nile Perch in Lake Victoria constituted about 66 % of the total catch at its peak in 1990 (Mkumbo and Marshall 2015), but its introduction has been described as a socio-environmental failure from the perspective of impacts on local human communities (Von Kaufmann 2007), presumably with attendant reduced resilience. The *paiche* fishery in Bolivia, perhaps most advanced in Trinidacito, has shown some evolutionary steps reflecting the Holling cycles of resilience thinking (Holling 1973; Walker et al. 2004). These steps have been fostered by community cohesion, created through conflicts over access and the distribution of benefits, but tempered by historical social capital from the rubber-tapping era of both positive organizational capacity and fiscally-oriented monitoring mechanisms that vary in effectiveness. An evolving local organization adapting to a changing resource base and external pressures has been able to demonstrate strengths and deficits in expanding community-based fishery management and fisheries practices. While fishers maintain a diversified seasonal livelihood strategy, they have also increased single species exploitation instead of a traditional focus on small-bodied native species. While the fishery is still too young to assess how long-term resilience and well being will be affected by the introduction of *paiche*, information reported here will help inform multiple scales of regulatory and development strategies to foster positive outcomes for indigenous communities that may take advantage of the new opportunity *paiche* presents.

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
AM and FMCV designed and implemented the study, performed data analysis and writing. AA participated in data collection and analysis and made contributions to the writing. TKR, PVD and JC participated in data analysis, writing and editing. All authors read and approved the final manuscript.

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Governability assessment of the Galapagos Marine Reserve

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Abstract

The Galapagos Marine Reserve is one of the most recognized marine protected areas in the world, due mainly to its unique natural features. Little is known, however, about its social counterpart. This research aims to explore the Galapagos Marine Reserve governance by following the governability assessment framework, which is based on the interactive governance perspective. We claim that improved governance and incresed governability of this marine protected area, ruled under a co-management mode of governance, cannot be achieved without comprehensive understanding about the Galapagos Marine Reserve's governing system, the systems that are being governed, and their interactions. Semi-structured interviews with a range of stakeholders were conducted as part of the study to illuminate the characteristics of the systems and how they interact. The analysis reveals a high degree of variation between the formal and operative structures of the systems, due largely to the complexity, dynamics, and diversity of the systems, and the multiple scales at which they operate. Further, our findings highlight that governing decisions, and thus the overall governance performance, are influenced by certain quality of the systems (e.g., inefficiency, vulnerability, misrepresentation). Along with the understanding of potential complementarity with other governance modes (e.g., hierarchical), the research identifies that the governability of the Galapagos Marine Reserve can be improved by making governance processes more transparent and by better consideration of the social component in the governing system. In that way, the marine reserve sustainability would also be enhanced.

Keywords: Interactive governance; Governability; Galapagos Islands; System analysis; Social system

Introduction

Different assessments of the performance of the Galapagos Marine Reserve (GMR) reveal that efforts put in monitoring the systems operation, reforming the organizational structure, and modifying practices of resource users and authorities still fail to fully respond to the its needs (Heylings and Bravo, 2007; Hockings et al. 2012; Toral-Granda et al. 2011; Jones, 2013). Threats to the marine ecosystemin the area continue, with several causes of the problem identified, such as illegal fishing, introduction of invasive species, marine pollution by chronic discharges, noise pollution, diving sites and marine-scape damage, biodiversity loss, and unsustainable practices in adjacent marine areas (Parque Nacional Galápagos PNG 2006; Benítez-Capistrósós et al. 2014). While these problems are acknowledged, they have not been properly addressed (WWF, 2003). This situation is considered to be critically limiting GMR's governability

(Parque Nacional Galápagos PNG 2006). In effect, the current state of marine ecosystem in the Galapagos suggests that governing GMRis more difficult than what it seems.

GMR has been governed to achieve managerial-based outcomes (Toral-Granda et al. 2011). One possible reason for this is the lack of recognition that management and governance are not synonymous (Armitage et al. 2012; Chuenpagdee 2011). Perhaps, Ludwig (2001) is right in saying that the management age "is over". Too much efforts have been expended in assessing management effectiveness (Toral-Granda et al. 2011; Hockings et al. 2012), allocation and renewal of fishing permits, monitoring and controlling post-harvest activities, and dealing with other management duties (Hockings et al. 2012). While these 'first-order' governance tasks are important (Bavinck et al. 2005), they do not address the fundamental issues affecting the human and environmental health of the GMR. A shift from resource management to ecosystem governance, with an understanding of human and natural sub-systems on their own and in how they interact, is required (Chuenpagdee 2011).

From a governability perspective (Kooiman et al. 2005, 2008; Bavinck et al. 2013), it has been recognized that the limits to marine protected areas (MPAs) governability can be better understood by a careful examination of its systems. Moreover, Chuenpagdee and Jentoft (2009; 2013) posit that the "overall governance quality" depends first and foremost on the inherent characteristics of the human and natural sub-systems that are being governed and of the governing system. These scholars claim that the MPAs governability is influenced and highly dependent on the nature and quality of the systems interactions. Consequently, by exploring governance of GMR we could benefit of a comprehensive understanding of what are the factors affecting GMR governability.

Some studies addressing GMR governance (FN and WWF 2000, FN and WWF 2001; Charles Darwin Foundation CDF, Galapagos National Park GNP, INGALA 2008, Charles Darwin Foundation CDF, Galapagos National Park GNP and INGALA 2010; Toral-Granda et al. 2011; Hockings et al. 2012) have dealt with the roles and scopes of these bodies, as well as described interests, positions, and conflicts of interest groups associated with the GMR.

Their deficiencies seem to be the lack of attention to the connectivity between the human and natural sub-systems and to their interactions with the governing system (in this case, the Galapagos National Park Service, GNPS). This has resulted in the GMR being managed according to the ability and capacity of the governing bodies, which is necessary but it may not be what those being governed, such as fishers and tourism operators, expect of them (see Song and Chuenpagdee, 2010). Our paper, on the contrary, focuses on the Interactive Governance (Kooiman et al. 2005; Bavinck et al. 2013) as the analytical perspective to address the governance of GMR, by systematically exploring the three systems described by this approach: the governing system, the system-to-be-governed, and their mutual interactions. In order to do so, we posit three research questions: how is GMR governed? What features of GMR's systems are influencing its governability? How can the governability challenges be addressed?

This research contributes to the discourse about governance of marine resources, and governability of MPAs and marine reserves, through the case study of theGMR. Its novelty rests in the application of acomprehensive, flexible and systematic governability analytical framework (Kooiman et al. 2005; Bavinck et al. 2013) that enables the illustration of the systems and their characteristics influencing governability. The premise

of our argument is that GMR governance is challenged by simultaneous and multidimensional factors. For the most part, the natural sub-system has been studied with higher emphasis, whereas the social sub-system has been overlooked and underestimated, and thus issues surrounding it have not been tackled with the same intensity (Snell et al. 1996; Tapia et al. 2009; Santander et al. 2009). Since this paper is about the governability assessment of GMR, the manuscript structure follows the format proposed by this framework to illustrate the systems under analysis and their constituting elements: the natural sub-system-to-be-governed, the social sub-system-to-be-governed, the Governing System and their interactions. Implications of the systems quality in GMR performance and governability are discussed and some conclusions about future implications in GMR governance are presented.

Methods

Several methods were used to collect data and to analyze the systems, including in-depth semi-structured and open-ended interviews with GMR stakeholders, informal conversations with key informants, field observations, attendance of local meetings, and review of secondary data (i.e., published governmental and non-governmental reports and grey literature). Informants included small-scale fishers, tour operator agencies, naturalistic guides, scientists, maritime transportation agencies, and GNPS staff members. They were approached through "snow-ball" sampling technique (Goodman, 1961; Biernacki and Waldorf 1981; Babbie 2001; Hernández-Sampieri et al. 2006) used as a referral process, to contact previously referenced names in order to increase the set of interviews. Further, the "key informant interview" approach (Walmsley, et al. 2005) was used as for gathering insights on subjects of interest within this research's context. Request of participation was made with potential interviewees either in person, by telephone or email. Sampling was theoretical (or purposive) (Mays and Pope, 1995), rather than random or representative (Kerr and Swaffield 2012).

Interviewed respondents were self-identified GMR stakeholders, based on their answer to the initial question about their relation to GMR, either individually or institutionally (i.e.,"What is your/your institution relation to the GMR?"). They were later asked to describe GMR current status. Additionally, they were invited to talk about the major issues happening in GMR at present and their influence in the current status. Finally, they were requested to share their thoughts about potential ways to address or solve those issues.

Following Mangi and Austen (2008) and Hamilton (2012), the interviews with fishers were at landing sites, on piers, or at their homes; whereas other participants were interviewed at their local offices or operating centres. In total, thirty-nine persons were interviewed, including eight tour operators, eight diving centers staff members, two naturalistic guides, eight small-scale fishers, five scientists, five park managers, and three employees of maritime transport companies. Four people declined to participate, due in some cases to their admitted lack of knowledge about the GMR, while in other instances because of their mistrust and discomfort of being interviewed.

The data collection period totalled about six months during three field seasons (2010, 2011, and 2012) and took place mostly throughout the rainy period. The interviews lasted about 50–60 min on average. All interviews were conducted in Spanish, with the written notes subsequently transcribed into English. After transcription from raw data, interviews were coded for content following Braun and Clarke (2006) thematic analysis

approach, which is an analytical process based on segmentation, categorization, and relinking of smaller sets of data before its final interpretation (Grbich 2007). It was used to identify common emerging themes or patterns within data that are important to describe the phenomenon under study. By carefully reading and re-reading the data, we examined, identified, categorized, analyzed, and coded datasets (Constas 1992; Chi, 1997; Nicholas and McDowall 2012; Zinda, 2012).

Coding implied finding common ideas, by examining, identifying, categorizing, and reporting data sets, as an iterative process of inductive line-by-line coding (Constas, 1992; AronsonJ 1994; Chi 1997; Braun and Clarke 2006; Nicholas and McDowall 2012, Zinda, 2012). After reading and marking the text, some significant passages were extracted (Seidman, 2006; Rubin and Rubin, 2005) and coded to conceptualize the ideas related to important aspects of the research (Rubin and Rubin, 2005). Certain judgement was exercised at this point while extracting "significant" segments from transcripts. Consistency in observation, labeling and interpretation was emphasized to increase reliability as suggested by Boyatzis (1998).

Quotes from participants have been used as supporting evidence and include a referential code, written in brackets, that represents the participant number and the date when the interview was conducted. Results from the system analysis are interpreted in terms of governability of the GMR.

Results - the GMR systems

The system-to-be-governed

The natural sub-system

The Galapagos archipelago are volcanic islands located 1000 km. off Ecuador, with a land area of about 8000 km^2, including 19 big islands,107 islets and rocks (Parque Nacional Galápagos PNG 2006; Baine et al. 2007) (Fig. 1). Despite early human presence on the islands (Heyerdahl and Skjölsvold, 1956), its official discovery occurred on 1535 (Latorre, 1999). The GMR fosters unique species of marine flora and fauna, compared to any area of its size worldwide (Bustamante et al. 1999), with almost 60 % of the species endemic to the area (de Groot, 1983; Bustamante et al. 2002; Parque Nacional Galápagos PNG 2006; United Nations Environment Program UNEP 2011). These geophysical and ecological features, along with the high biodiversity, productivity and endemism (Danulat and Edgar, 2002) of Galapagos marine environments, make the islands one of the most diverse and complex marine ecoregions in the world (Olson and Dinerstein, 1998; Olson et al. 2002; Bensted-Smith et al. 2002). The convergence of three major oceanic current systems in this area (i.e., Humboldt-, Panama-, and Equatorial Undercurrent) adds to the overall richness (Edgar et al. 2004; Baine et al. 2007; United Nations Environment Program UNEP 2011), creating three types of marine ecosystems characterizing the GMR, i.e., coastal zone, shallow waters, and deep seas (Banks 2007; Castrejón 2011). The importance of the natural sub-system is well recognized, reflecting in the protection of the 40-miles zone of marine environments around the archipelago under GMR (Fig. 1), after the special law declaration in 1998.

Marine species in the GMR are either resident or transient, depending on the nutrient supply from the ocean currents, temperature, and current strength (Galápagos Conservation Trust 2013). Their distribution is uneven with high concentrations of marine taxa (e.g., sharks, stingrays, and sea turtles) in pelagic zones of deep waters

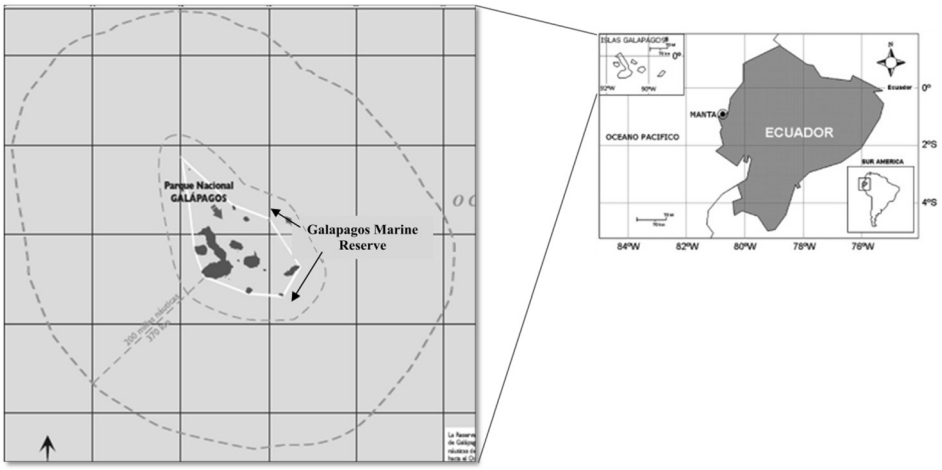

Fig. 1 GMR natural system (Modified from ECOLAP and MAE, 2007)

depression and sea mounts around Isabela, Fernandina, and Wolf (Hearn et al. 2010; Galápagos Conservation Trust 2013). These marine species vary in their importance to different sectors, and in terms of how well they are managed, as shown in Table 1. These features of the natural sub-system of the Galapagos create governability challenges, resulting, for instance, in some species being better managed than others.

The social sub-system

Permanent human occupation in Galapagos dates from 1832, when the archipelago was officially annexed to Ecuador's territory. At that time, given the position of Galapagos as an strategic point within inter-oceanic maritime routes between Central and South American toward Asia, Polynesia, and Australia (Luna-Tobar 1997), the islands were object of considerable geopolitical interest by imperial maritime powers (Celata and Sanna, 2010). By then, the Ecuadorian State faced pressure to claim the islands as territory under its national sovereignty. Additionally, during the WWII until late 1960s, a U.S. Navy Base operates in Baltra Island (Grenier 2002; Finley 2009). Currently, Galapagos Islands are one of the twenty-four Ecuadorian provinces and host over 30,000 inhabitants, both in urban and rural settings (Instituto Nacional de Estadísticas y Censos INEC 2010). This population originated from the first large migratory movement, that thrived in the early 1990s, as a consequence of the sea cucumber fishery explotion (Ospina and Falconí, 2007; Grenier 2007a).

Currently, there are at least 1100 fishers holding permits to fish in Galapagos, locally known as PARMA license (Parque Nacional Galapagos PNG 2012; Palacios and Schuhbauer, 2012). Of these, only between 400–470 are commercially active (Palacios and Schuhbauer, 2012; Schuhbauer and Koch 2013). The tourism sector includes tour agencies, diving centers, and naturalistic guide operations. Maritime transportation has dozens of speedboats (Denkinger et al. 2013), providing inter-island transportation services. The islands also host a number of scientists, although there is no official record of their number. Finally, the GMR management staff represents a sizeble sector of the island population, distributed between the headquarters in Santa Cruz, two technical units in San Cristobal and Isabela, and a technical office

Table 1 Key marine species for fishing and tourism sectors of Galapagos and their management and ecological status

Taxa	Scientific name	English name	Status
Invertebrates	*Isostichopus fuscus*[a]	Sea cucumber	Managed[b, c]
	Panulirus penicillatus[a] and *P. gracilis*[a]	Spiny lobster	
	Scyllarides astori[a]	Slipper lobster	
Fishes	*Carcharhinus galapagensis*[d]	Galapagos shark	Vulnerable[b,e,c,f]
	Triaenodon obesus[d]	Requiem shark	
	Sphyrna lewini[d]	Hammerhead shark	
	Mycteroperca olfax[a]	Galapagos cod	
	Rhincodon typus[d]	Whale-shark	
	Thunnus obesus[a]	Pacific bigeye tuna	
	Acanthocybium solandri[a]	Wahoo	
	T.albacares[a,c]	Yellowfin tuna	Nd
Reptiles	*Testudine* sp. [d]	Giant tortoise	Managed
	Conolophus subcristatus [d]	Land iguana	Nd
	Amblyrhynchus cristatus [d]	Marine iguana	Vulnerable[g]
	Chelonia mydas agassizii [d]	Green sea turtles	Endangered[g]
	Lepidochelys olivacea [d]	Olive-ridley turtle	
	Dermochelys coriacea [d]	Leatherback turtle	Critically Endangered[g]
	Eretmochelys imbricata [d]	Hawksbill turtle	
Birds	*Sula nebouxii* [d]; *S. sula*[d]	Blue-&red-footed booby	Nd
	Phoebastria irrorata [d]	Waved albatross	Vulnerable[g]
	Larus fuliginosa[d]	Lava gull	
	Spheniscus mendiculus [d]	Galapagos penguin	Endangered[g, c]
	Phalacrocorax harrisi [d]	Flightless cormorant	
	Pterodroma phaeopygia[d]	Galapagos petrel	Critically Endangered[g]
Mammals	*Zalophus wollebaeki* [d]	Galapagos sea lion	Vulnerable[g]
	Arctocephalus galapagoensis [d]	Galapagos fur seal	
	Physeter macrocephalus[d]	Sperm whale	
	Megaptera novaeangliae[d]	Humpback whale	
	Balaenoptera musculus[d]	Blue Whale	Endangered[g]

[a]Species with economic interest for the local small-scale fisheriessector (Danulat and Edgar, 2002; Castrejón 2011)
[b]Edgar et al. 2004
[c]Luna et al. 2012
[d]Species with interest for tourism sector (Quiroga 2009 unpublished)
[e]Castrejón, 2011
[f]Jobstvogt, 2010 unpublished; nd (no data)
[g]Edgar et al. 2008

in Floreana (Parque Nacional Galapagos PNG 2014). Information about the key sectors that the study focused on are presented in Table 2.

The diversity, complexity and dynamics observed in the social sub-system of the GMR are to be expected given the characteristics of the natural sub-system. Small-scale fishers in Galapagos, target several pelagic and demersal species. Reports show that 25 % of the total catch correspond to the Misty grouper (*Epinephelus mystacinus*); 16 % to the Galapagos sail-fin grouper (*Mycteroperca olfax*); 7 % to the Wahoo *(Acanthocibium solandri)*; and 16 % to the Yellow- and Black-tailed mullet (*Mugil galapagensis* and *Xenomugil thoburni*), and to the Yellow-fin tuna (*Thunnus albacares*)

Table 2 Demographic information of the key interest groups

Sector	Island			Active
	Santa Cruz	San Cristobal	Isabela	
Small-scale fishers	262[a]	520[a]	241[a]	400[b]- 470[c] (1,035[d]-1,216[c] officially registered)
Tourism Operators[e]	53	25	9	87
GNPS personnel				238[f]-334[g]
Tourism boats' permits				89[d]- 90[e]

[a]Fishers associated with cooperatives (Source: Castrejón 2011). [b]Schuhbauer and Koch (2013); [c]Palacios and Schuhbauer (2012); [d]Parque Nacional Galapagos (PNG) (2012);[e]Tourism Ministry (2011); [f]Rozzi R et al. (2010); [g]Parque Nacional Galapagos (PNG) (2014). Numbers in the "active" column includes Floreana records

altogether. Less common species made 20 % of the total catch including theMottled scorpionfish (*Pontinus clemensi*), the Whitespotted sand bass (*Paralabrax albomaculatus*), the Almaco jack (*Seriola rivoliana*), the Ocean whitefish (*Caulolatilus princeps*), and the Dog snapper (*Lutjanus novemfasciatus*). Finally, 16 % were represented by other species (Molina et al. 2004). The sea cucumber (*Isostichopus fuscus*) fishery in 2004 involved 874 fishers and 446 boats (Hearn et al. 2004a),whereas the spiny lobster (*Panulirus penicillatus* and *P. gracilis*) fishery in the same year included 657 fishers and 309 boats (Hearn et al. 2004b).

Fishers in Galapagos apply diverse fishing practices and gears with varied effectiveness. For example more than 70 % of the catches, mostly demersal species, are from *empate* (pasive gear with line and hooks); whereas 16 % are obtained with the *señuelo* or *pluma* (active gear of line with hook) including mainly pelagic species, and 11 % of catches correspond to gillnets and mostly include coastal-pelagic species (Molina et al. 2004). Sea cucumber and spiny lobster fishery are almost exclusively restricted to diving-collection practices (Table 3). Catches were once exclusively used for local consumption, but demand for salt-dried (cured) filets of the Galapagos-sail fin grouper triggered higher catches and increased exportation since the late 1980s.

Maritime tourism is another key aspect of the GMR social sub-system. It is conducted by local, national, and international agencies and operates at different scales. The larger businesses are ship-based cruises, while sailboats, daily-tour boats and transportation ships operate on a smaller scale. Additionally, a deluxe-type of tourism is represented by "mega yachts," five to ten of which arrive in Galapagos each year.

Other groups and individuals form a constellation of interest groups in the GMR. Officially, there are *ca.* 220 civil society and governmental groups in the area related to conservation, farming, sports, elderly people, religious, trade, and volunteerism (Watkins and Martinez, 2008). Some of them have been present in Galapagos for more than five decades, e.g., Charles Darwin Research Station, whereas others have been recently created (especially religious associations and volunteer agencies). Among them, conservation and volunteer-related groups are directly connected to the GMR.

The complexity and dynamics of the social sub-system of the GMR are amplified by the disparity in contributions from each sector to the local economy and by the unequal allotment of funds within the interest groups. This unevenness generates tension and represents potential source for conflicts. One example is the influential role that the tourism sector plays locally, compared to other sectors, due to the significant amount of money circulating around it. Of about US$ 73.22 million in

Table 3 Gears and boats used in finfish fisheries

Fishing boats		Fishing method	Frequencyofuse [a]	% of total landing caught with this gear [a]
Pangas[b]	3,8 – 8,3 m. long, open wood boats; 10–85 HP engines	Empate[c]	Very high	71
Fibras[1]	5- 9,6 m fast fiberglass boats; 25–200 HP engines	*Señuelo/pluma* (Lure)	High	16
		Hawaiian spear	Medium	2
Boats	8 – 17,5 m. long wooden boats; 30–210 HP engines	Beach seine	Medium	11
		Chinchorro (Shore seine)	Low	2
		Hook and line	Low	2
		Diving (compresor)	High	*ca.* 100 %

Source: modified from von Gaegern (2009 unpublished); Castrejón (2008 unpublished)
[a]Molina et al. (2004); Hearn et al. 2004a, b
[b]These two type of boats compose almost 85.5 % of the registered licenses in GMR (Castrejón, 2008)
[c]Called "*línea de mano*" or "*cordel*" (Nicolaides et al. 2002); is a simple handline fishing gear (von Gaern, 2009) using a line with hooks joined at different levels in a vertical disposition

Gross Island Product in 2005, more than 65 % came from tourism and tourism-related activities (e.g., equipment rental, locally and mainland-based cruiseship), with an average income of US$ 85 million per year (Epler 2007; Taylor et al. 2009). Additional earnings came from fishing and fishing-related business (8 %), commerce (8 %), agriculture and livestock (5 %), and services (e.g., restaurants, bars) (7 %),with the rest coming from transportation, household resources extraction and processing (e.g., water), and other activities (Epler, 2007). In this context, fisheries contributed to Galapagos economy with an average income of US$2-7million per year (Hearn et al. 2006), with the highest amount during sea cucumber season of 2005 when US$6 million were earned from this activity alone (Portilla 2005 unpublished, United Nations Environment Program UNEP 2013, Taylor et al. 2009). Furthermore, management (in 2001) and scientific sectors (between 2002–2006) have contributed to the local economy with US$5.3 millions (from GNPS entrance fees) and with US$11 millions (from national and international donors), respectively (González and Tapia 2005; BID 2006; Ospina 2006; WWF-USAID 2006; Castrejón et al. 2014).

With respect to funding allocation, between 1999–2005, 63 % of the total national and international funding was invested in biodiversity conservation in Galapagos, whereas only 37 % was alloted to human development (Salcedo-Andrade, 2008). The National Park authority (Dirección Parque Nacional Galápagos DPNG 2014) reports the distribution of the funds within Galapagos bodies as follows: GNPS (45 %), Autonomous Local Municipalities (25 %), Government Council (20 %), Navy (5 %), and the National Agency for Health and Harmlessness in Agricultural and Cattle-harvesting activities (AGROCALIDAD) (5 %).

Such disparity generated sectoral conflicts, particularly with small-scale fisheries who felt that they were taken advantage of by the way funds were raised and allocated, as expressed by one interviewee.

> "They [conservation and research bodies] hide behind the small-scale fisheries sector to get funds. They invite us to participate, offer us coffee and spend thousands of dollars that were donated in name of the fishing sector" (P25, 26.05.11).

The social sub-system is further convoluted by scale issues associated with the lack of well-defined boundaries. For instance, the categories "residents" and "non-residents"used by government officials, according to the local rules, do not align with how local people recognize each other, which is based on the time of their arrival to the islands, as suggested below.

> "[T]he population [is divided]into groups or segments, in order of arrival to the islands: the first settlers, the intermediate settlers, the new migrants. They [the first settlers] were at the beginning, the first opponent to the delimitation and formation of the protected area as GNP. Those who most support the conservation of the islands [at present] descend from them. The second are the *colonos* interested in doing business and earning money. They are business people who were little by little involved in the islands, and in the long run, through marriages with locals or children being born here, became "locals" also attached to the islands. The third group is the new migrants. They never had real attachment to the place; they regret having arrived here, and want to be back [tothe mainland] but cannot due to lack of money […]. They have not adapted to this placeand always intend to have a mainland lifestyle" (P05, 21.07.10).

This distinction plays a role in the perception that *Galapagueños*[1] and non-*Galapagueños* have of each other, which is likely a reflection of their vision about the sustainability of the islands.

On the whole, the above characteristics (i.e., complexity, diversity, dynamics and scale) of the natural and social sub-systems of Galapagos create challenges to the governance of the GMR, and contribute to lessen the overall system governability. While not much can be done to change some of the more inherent characteristics, certain governing interventions may result in changing some aspects of these systems, making them more governable. Whether and how this will happen will depend on the features and capacity of the governing system, as later discussed.

The governing system

The GMR is governed by a co-management system, which is novel in Ecuadorian standards. It represents a shift from a traditional hierarchical approach toward a horizontal management model, operating under three key principles: participation, adaptive management, and precautionary principle (Baine et al. 2007; Heylings and Bravo, 2007). The two managerial bodies created in order to facilitate the co-management model are the Participative Management Board (PMB) and the Inter-institutional Management Authority (IMA). Both provided ground for the different interest groups in the GMR to legally participate in decision and policy making (Heylings and Bravo, 2007; Castrejon 2008).

The PMB (locally known as "*La Junta*") is the local executive forum for advice and consultation about concerns regarding the GMR. It comprises of representatives from the local small-scale fisheries sector, the Galapagos Chamber of Tourism, the

Naturalistic Guides Association, the Science and Education sector (initially represented by the Charles Darwin Research Station) and the management sector (represented by the GNPS serving as the executive arm of the GMR). Inside the PMB, the GNPS represents the executive arm of the GMR at implementing the management plan (Heylings and Bravo, 2002; Parque Nacional Galápagos PNG 2006; Baine et al. 2007). It is within the PMB that nterest groups can submit proposals about issues that require deliberations and consensus.

The IMA is a ministerial forum of decision making, based on Ecuador's mainland. It is formed by the Ministries of Environment (acting as President), Agriculture-Cattle-Aquaculture-and-Fisheries, Tourism, and Defence. Additionally, it invites representatives of the Ecuadorian NGOs Network (CEDENMA) and local sectors (i.e., the small-scale fisheries and the Galapagos Chamber of Tourism). Furthermore, it includes the Charles Darwin Research Station (acting as Technical Advisor) and the GNPS (acting as Technical Secretariat for the Environment Ministry) (see Fig. 2).

In cases where consensus is not achieved at the PMB level, the proposal is still forwarded to IMA for resolution, accomplished through a majority voting system. The IMA resolution becomes binding and must be executed by the GNPS and/or its advisor(s). Additionally, when urgent actions are needed, GNPS can take decisions by direct resolutions independently from both boards (Parque Nacional Galápagos PNG 2006; Baine et al. 2007).

One of the key management instruments employed by the governing system is zoning of the protected area with differentiated activities allowed within it (e.g.,tourism, small-scale fisheries, scientific research, management, and maritime transportation). This zoning system describes three main areas: multiple-use zone, limited-use zone, and harbor-zones. Our study found, however, that despite the consensus about the zoning, disagreements regarding its implementation still exist.

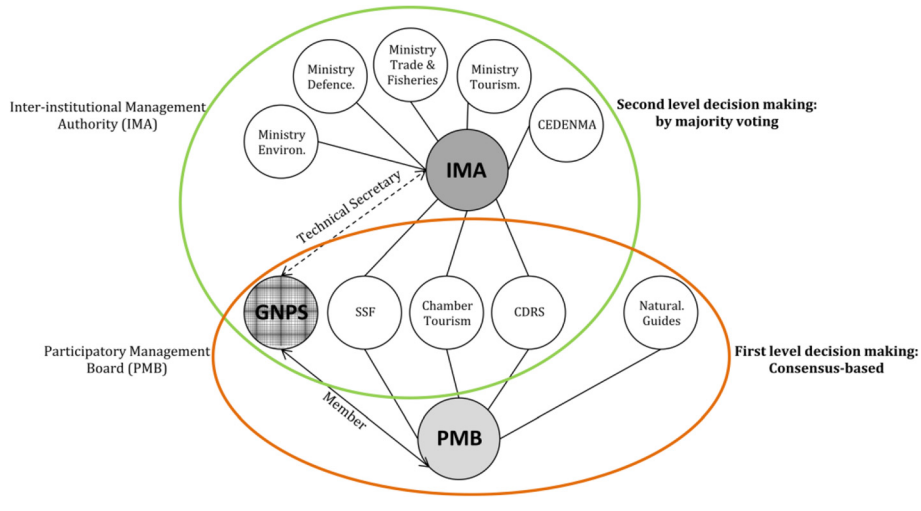

Fig. 2 GMR's Governing System (Source: modified from Parque Nacional Galápagos PNG 2006; Heylings and Bravo, 2007; Baine et al. 2007)

"They [GNPS] control the fishing sector chasing us [fishers]....the tourism sector has always had advantages over us [small-scale fisheries sector]. If we use a fishing site, then they [GNPS] come, displace us and give that site to the tourism sector. They [the tourism sector] are more powerful than us…"(P26, 07.06.11).

"They [fishers] come to the diving sites and use the place to eviscerate their catches. This annoys us because they '*alborotan*' [whip] the sharks [up]...."(P35, 06.02.12).

These disagreements reflect the complex relationship between the interest groups in the GMR. For instance, sectors with representatives in the PMB are likely able to influence decisions at that level. Similarly, those with economic wealth and those with scientific knowledge are seen to have a stronghold in what goes on in the area.

"Scientists, with their studies [the research done by them] and with their preparation, they are the ones who are able to give their opinion" (P31, 23.03.12).

"Here, decisions are taken by NGOs, what they want… that is what is decided" (P21, 22.03.12).

"Business owners from tourism and fisheries sector [boat owners] are those with high influence. Even more, some of the boat owners are based on Guayaquil or Manta" (P35, 09.04.12).

The co-management horizontal mode shaping the governing system of the GMR has undoubtedly created multiple opportunities for the social sub-system to take part in decision and policy making processes. However, despite its recognized value, there still are limitations of this management mode at improving the overall governability of the systems. Whereas it has managed to control and limit fishers' access to some marine resources, there is no evidence about what this governing system has done to set limits for the tourism activity. In fact, little progress has been achieved by the governing system in mitigating the push and pull effect of tourism over migration and the consequences derived from it.

The governing system is formally described as participatory in nature, under the co-management scheme. Our analysis shows, however, that in practice it follows a rather hierarchical characteristic. As shown in our study, while the co-management arrangement is effective in bringing traditionally opposed sectors (e.g., conservation, small-scale fisheries, and tourism) to the same decision-making table, operationally, the participatory quality of the governing system is questioned. This sentiment is expressed by several people interviewed in the study.

"Everybody says that it [the participatory process] works, but, does it really work? or at the end of the day is everything done as [one] person dictates?" (P23, 20.05.10).

"The first and last word is taken by the GNPS. They meet, they decide, accept and publish everything before we are aware of it. They tell things to us only when

everything is done. They do not take us into account…we are not part of the decisions" (P31, 13.06.11).

"To take decisions, nobody asks for opinion. The [decision making] groups are only made by their own with the GNPS and private institutions" (P3, 01.02.12).

This perceived failure is related to three key aspects of marine resource governance, according to Jentoft (2000), Mikalsen and Jentoft (2001), and Buanes et al. (2004), i.e., legitimacy, power and urgency. In the GMR, legitimacy of some of the users' representatives in the governing body is contested. Furthermore, those being represented claim that leaders taking part indecision and policy making on their behalf are not fully entitled by their own sectors, but are instead enabled by their power and influence at higher levels (Marder and Arcos, 1985). Still, power within the PMB and IMA, are characterized by levels of influence unequally distributed among the different actors, often resulting in the marginalization of the less powerful of the sectors represented there. And urgency, considered as the degree to which stakeholder claims call for immediate attention (Buanes et al. 2004), which in GMR is perceived to be defined by the interest of the most powerful actors within the PMB and IMA.

"The problem is the bad administration of the small-scale fisheries sector…Those who are the 'heads' [the fishers cooperative's representatives] only care about their own benefit …or their friends or relatives" (P26, 07.06.11).

"There is not a good representation of the fishers by the administrators [fisher's leaders]. They do not have accountability Nobody knows how much they earn, how much they spend, where they invest the money….Only when the people [fishers] get fed up, they [fisher's leaders] are requested to render accounts. And because they are not able to do that, they are kicked out….but there are no changes, it is always the same" (P26, 07.06.11).

"Another interesting factor is the legitimacy. What is legitimacy? What is legitimate or illegitimate? Legitimacy is the perception of the world. The basics here are the multiplicity of interests that are in play. What the actors are interested in, determines the form, level, intensity and trend in the participation. The determinant issue is what motivates their interest? How is the interest used? Is this interest legitimate or illegitimate? Is there a dominant interest?… If there is interest, there is participation" (P01, 22.07.10).

In sum, the co-governance arrangement of the PMB facilitates local discussion about important issues affecting local stakeholders while IMA provides additional avenues for decision-making. The multi-level governance structure, with the majority of actor groups involved in both local and national governance, offers some advantages and disadvantages. For instance, issues can be dealt with locally and timely, but actors can also influence decisions at the national level, if they find local-level decision unsatisfactory. Various governing interactions take place within the governing system, which

may foster or impede governability, depending on their nature and quality, as further discussed.

The governing interactions

The interactions understood as "associated infrastructures" (Anderies et al. 2004) are characterized by the rapports taking place between and among the GS and the SG's sub-systems (Kooiman 1993; 2003). In GMRthe interactions are diverse, dynamic, and complex. In general terms, interactions between the GS and the two SG sub-systems are influenced by two conditions: the excellent knowledge of the natural subsystem and the deficient quantity and quality of the social subsystem understanding. The reason for this is the overestimation of the former against the underestimation of the latter. For instance, the GI, at decision and policy making between GS and natural SG, have been dominated by good quality and quantity of information regarding habitats health, marine resources status, and threats. Opposedly, the GI between GS and SG-social subsystem are almost restricted to the compliance and enforcement of the *LOREG*, via law observance, enforcement, and prosecution.

Additionally, some GI mechanisms taking place in GMR coincide with those illustrated by Song and Chuenpagdee (2010): participation (e.g., fishers taking part of priority issues identification at PMB); communication (e.g., through information published by research institutions); collaboration (e.g., by co-executed projects between GNPS and CDRS staff); and adaptation (e.g., by fishing quotas and/or ban establishment).

Discussion

Previous governance assessments of GMR (Heylings and Bravo, 2007) described the legally-based multi-stakeholder co-management regime currently responsible for all decisions on marine resources management within the reserve. They evaluated GMR governance based on quantitative and qualitative criteria provided by rankings given to issues addressed along the participatory processes. Furthermore, Castrejón et al. (2014) analyzed two local institutions (i.e., Galapagos National Park Service and Charles Darwin Foundation) as the key drivers of fishery science in Galapagos, illustrating the different periods in this scientific development. Finally, Jones (2013)tackled governance and management effectiveness by illustrating diverse strategies to achieve the outcomes (e.g., incentives) and some important issues occurring within the GMR area. Adding to this body of literature, our research takes the GMR governance analysis to another level,with the interactive governance and governability lenses. We illustrate this with the discussion below, framed in the context of the research questions, i.e., how GMR is governed, and the features of the GMR's systems that influence its governability.

Formal vs. operative nature of the GMR

Disparity between formal and operative nature of the GMR is found in all systems (Fig. 3). Consequently, it can be argued that GMR is governed differently from what the theory calls and what the practice unfolds. While the natural sub-system claims relative "pristine" condition as its formal description, the state of the social sub-system is practically unknown. From the governing system perspective, the natural sub-

	System-to-be-governed		Governing system
	Natural system	Social system	
Formal	Territorial-provincial space	Sectors / bottom-up	Participatory
Operative	Zoning	Networks / top-down	Hierarchical

Fig. 3 Formal and operative features of GMR's systems

system is formally managed as a territorial sea. Yet, in practice, a zoning system is used. On the social side, the human activities are formally described to be circumscribed to the sectors functioning with a bottom-up approach whereas operationally, they perform network-based features within top-down attributes (Dirección Parque Nacional Galápagos DPNG 2014).

The inherent attributes of the governing system and the systems that are being governed –in their formal and operative shapes–are compromising the governance quality of the GMR (Dirección Parque Nacional Galápagos DPNG 2014). For the most part, the technical solutions employed by the governing system based largely on the natural scientific knowledge have insufficiently addressed the challenges related to either the environmental sustainability or society's wellbeing (Jameson et al. 2002; Quiroga, 2009). One illustration of this is in fisheries where rules and regulations provided by the operative hierarchical governing system do not take into account the dependency of fishing people on the marine resources. In other words, the 'network-based' social sub-system requires a different governing system that is not zoning-based, which is what applies to the natural sub-system.

In addition, historically, prosperity in Galapagos came from small-scale fisheries but increased with tourism development, commerce and building construction. The formally described participatory governing system has emphasized fishing and fisheries as its main target. However, it has rarely acknowledged the implications of the extensive dependency of the local economy on tourism and its vulnerability to globalized mechanisms such as international markets, state-safety policies, and risk perception (Baine et al. 2007; Beck, 2011). Instead, this governance mode supports tourism, which as a network-based business of hierarchical nature, is closer to global geopolitics, economic trend, and to Ecuadorian national politics than to the sustainable practices needed in GMR.

It should be noted that in Galapagos, the dynamics of both industries are influenced by local and national fish markets and also tourism global demand, as direct exogenous influential factors. This globalized force has decreased the archipelago isolation and opened doors to the outside world (Grenier, 2002, 2007a,b; 2009; 2010). Naturally, globalization brings with it more complexity and dynamics, which may affect the system governability. The governability of the GMR would be deeply linked to how these global- or locally-based factors influence all the GMR systems.

Features influencing GMR governability

On a positive side, it could be argued that the currrent co-management governing mode contributes to the GMR stability, permanence, continuity, and credibility. Additionally, it can be seen as fostering participation of a great diversity of institutions and actors associated with a wide range of activities, origins, competences, and functions, each with different level of involvement and commitment. Finally, the double role that

some of the governance actors play within the PMB and the IMA (e.g., GNPS, small-scale fisheries, tourism, and science as shown in the overlapping area in Fig. 2) broadens their possibilities to influence decision and policy making. Nevertheless, the co-management system faces certain challenges. For instance, the members' participation is influenced by legal, ethic, and moral attributes, which are not necesarilly voided of competing interests, power position, and economic influence. Consequently, the governing processes depend on where, how,and by whom marine resources are used, managed, and governed, as well as whether they are based on short-term or long-term interests.

On the negative side, there are some factors affecting governability of the GMR. One is the misalignment observed between the formal and operative features of the governing system and of the natural and social sub-systems-to-be-governed. In fact, the GMR governability is likely to be diminished when the participatory governing system operates hierarchically by dictating rules, compromising therefore ethical and moral realms of the social sub-sytem. For example, two of the three principles that provide the basis for the GMR creation, i.e., participation and adaptive management, are not fully followed, with the exclusion or restriction of access of local users to some marine resources (Baine et al. 2007; Heylings and Bravo, 2007). Fairness and justice question arises when local users are obliged to used damaged areas, whereas the more pristine environments are kept for foreign divers or exclusively reserved for wealthy people visiting the area as tourists.

Additionally, the governance of the natural sub-system based on the imposition of regulations to only one segment of the social sub-system (i.e., fisheries) has been claimed not only to diminish the resilience of local fishers, but also to threaten the basic right of humans to access to a decent livelihood. Evidence of this is the occupation displacement when the first and second generation of Galapagos fishers could no longer stay in the fisheries. Neither could their children and other younger generations. Instead of fishing, some of them become nature guides or switch to other primary activities (e.g., agriculture), to services sector (e.g., tourism, transport, logistics), and even to administrative positions (e.g., politics, bureaucratic roles). Unfortunately, they do not always succeed.

Moreover, the interactions between GS and SG-natural and social sub-systems are not effective partly because the overwhelming existing knowledge about the natural sub-system versus the incomplete understanding of its social cunterpart. Consequently, GI are eventually built over knowledge gaps, addressing social dimensions as if they would be nature-based issues. That approach clearly reduces the governability of the system, and its governance quality, which in Watkins and Cruz (2007:4) words are due to the tendecy to "base decisions over assumptions and perceptions instead on solid information".

Furthermore, the territorial-provincial quality of the natural sub-systems contradicts the intention to conserve them. The dual status of "the province-protected area model" (Salcedo-Andrade 2008) and the overlapping scopes of the bodies involved in the GMR governance (e.g., institutions of the PMB, IMA, and local municipalities), are certainly uneven. Galapagos is a Special Territory but still holds features of other Ecuadorian provinces. Thiscontradiction escalates the dilemma between keeping the benefits provided by an expanding economy, or maintaining the aesthetic gains of an

unspoiled nature (Guha 2005). Failing in addressing these issues dangerously conspires against the GMR governance in the long run.

Consequently, human-related issues (e.g., food security) that could be not evident as challenging the GMR governance are present, due to the governing system implementation (i.e., the zoning system). For example, regardless of the limited access of local fishers to fishing grounds, the local demand for fish (e.g., by restaurants, hotels, and cruise ships) will remain and will be likely supplied by external sources, either from the mainland or from abroad. An example was provided by an interviewee about octopus imported from the mainland for local consumption in Galapagos and being re-exported back to the mainland, with the label of "Galapagos' octopus". This situation implies that prices of fish products would increase, with access to fish by local residents being reduced. Possible consequences of this would be malnutrition and mental health issues, including the emergence of feelings of unhapiness, exclusion, and marginalization. As seen in many places, the 'weak and unhappy' social sub-system could easily generate governability problems in the long-run (Axelrod 1994; Blount and Pitchon, 2007). On the contrary, tourism has only slightly been recognized as an "indirect" driver (Dirección Parque Nacional Galápagos DPNG 2014) for the effects on Galapagos environment, which disregards the real effect of this industry on the islands sustainability.

We argue that threats on the GMR cause stress simultaneously on both, natural- and social sub-systems. More emphasis is required then to understand the latter and incorporate such knowledge in decisions and policy-making about the GMR. The study also highlights the need to recognize that neither co-management nor hierarchical governance models, on their own, provide solutions to the GMR conflicts. Additionally co-management has demonstrated not to be the panacea but instead only one governing mode that needs to be adapted to the GMR system's own qualities and context. If this outcome is achieved, the systems would likely be more governable, their governance would improve, and the system's "long-term robustness" (Anderies et al. 2004) would increase. The co-existence of this co-governance mode with another (e.g., hierarchical governance) within the same nation-state (e.g., GMR and Ecuador mainland) does not taint the essence of the horizontal governance approach maintained in Galapagos.

Indeed, the Ecuadorian National Constitution under the "*Buen vivir*[2]" (or good way of living) paradigm, invites as the existence of harmonizing mechanisms to improve well-being and sustainability of social and natural sub-systems at a larger national (or regional) scale. A positive sign that GMR authorities may be keen to follow this recommendation is the shift experienced on the protected areas management approach presented by the new Galapagos Management Plan (Dirección Parque Nacional Galápagos DPNG 2014). For the first time in its history, Galapagos has a unified management instrument for both terrestrial and marine protected areas. This initiative, despite its still dominating managerial-based focus, responds to a national vocation (and regional trend in Latin American countries) to give a sense of unity and comprehensiveness to the state-ruled institutions (e.g., Galapagos Protected Areas) within their corresponding nation-states.

Conclusions

While the GMR governing system has shown to be stable, it is rather complex and inefficient due to the differences between its formal and operative design. Additionally,

the system-to-be-governed includes two sub-systems, which have received differently attention. On the one hand, the natural sub-system-to-be-governed has been shown to be diverse, dynamic, well monitored but vulnerable to the stress triggered by tourism and migration. On the other hand, the social sub-system-to-be-governed is under-represented within the governing system. In that regard, the quality of the participatory process is contested, low legitimacy is an issue, along with concerns about strong influence of power at decision and policy making. Finally, the lack of compliance, disappointment, and dissatisfaction from resource users greatly contribute to limiting the governing interactions and making them ineffective.

Recognizing that governability is the overall governance quality, and that it depends, first and foremost, on the characteristics of the system that is being governed, on the capacity of the governing system, and on the quality of their interactions (Song and Chuenpagdee, 2010; Bavinck and Kooiman, 2013; Bavinck et al. 2013), our research shows that GMR governability is reduced. The mismatch identified between what is needed by the natural sub-system (ecosystem health),what is expected by the social sub-system (social wellbeing), and what the governing bodies expect to accomplish (e.g., the six basic objectives of the Galapagos management programs, Dirección Parque Nacional Galápagos DPNG 2014:117) conspire against the improvement of the quality of these systems interactions. In that regard, on the one hand the decisions,policies, and assessment of the governing capacity are mislead. On the other hand, the passive resistance of the social sub-system at ignoring, infringing or violating the GMR's regulations, complicate governance of GMR.

Addressing these shortcomings would require enhanced transparency and improved participation. But at the end, increasing GMR governability must also involve addressing simultaneous and multidimensional factors like ongoing social problems (e.g., criminality, teenage pregnancy, drugs abuse). Their solution must have the same urgency as those regarding fishing quotas and tourism permits, recognizing that neither political indifference nor environmental fundamentalism will solve the challenges to the GMR governability.

Endnotes

[1]Demonym for people born in Galapagos.

[2]*Buen Vivir* (or Sumak Kawsay in Quichua language) is defined as "*the culture of life*". This notion was inserted in Ecuador's (2008) Constitution as the superior aim to be achieved by the State and by the entire society. It is based in an Andean tradition that qualifies a "good way of living" which is not lead by an ethics of unlimited progress, competition, or as a strategy to "life better". Instead, it is guided by a cosmological vision central to the philosophy of life held by indigenous societies in Andean South America. It is certainly not a construction manual for a better world. It presents itself as an opportunity to collectively design new forms of living with a remarkable and profound collective spirit. Been arisen from traditionally marginalized groups, and with a holistic point of view, the *Buen Vivir* is enabled by a diversity of factors characterizing human actions (e.g., knowledge, codes of ethical and spiritual behavior toward the environment, human values, and visions, among others). It is subject to a permanent process of construction and reproduction. In the words of the Brazilian theologian Boff: "[T]he *Buen Vivir* points to an ethic of that which is enough for the whole community,

not just for the individual. This notion implies an integrating holistic vision of the human being, immersed in the great earthly community, including, besides humans, the air, water, soil, mountains, trees, and animals; it must be in profound community with *Pachamama* (Our Mother Earth), with the energies of the Universe, and with God." (Houtart 2011; Acosta 2012).

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
MJBP and RC formulated research questions and conceived study design. MJBP collected and analyzed primary and secondary data, and prepared initial drafts. Writing of the manuscript took a collaborative effort as well as the revision of the manuscript in response to reviewers' comments. All authors read and approved the final manuscript.

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Towards adaptive co-management of small-scale fisheries in Uruguay and Brazil: lessons from using Ostrom's design principles

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Abstract

The literature on commons has established the validity and significance of Elinor Ostrom's design principles for collective action. Can these principles be used to guide policies and initiatives towards adaptive co-management? We analyze this idea by using two case studies, Piriápolis (Uruguay) and Paraty (Brazil). Both cases are small-scale fisheries, and both have been experiencing a social-ecological crisis in a context of prevailing top-down government management. However, there are signs that government policies are moving towards participatory governance. The objective of this article is to identify opportunities and barriers to adaptive co-management of small-scale fisheries in Uruguay and Brazil using Ostrom's design principles for guidance. Both case studies partially meet seven of the eleven design principles (as amended by Cox and colleagues), but do not fulfill four. The analysis of the fisheries using Ostrom's principles sheds light on the opportunities and barriers to adaptive co-management in three categories: resource system, resource users, and governance system. Barriers include long-standing conflicts between small-scale fishers and government agencies, and between small and large-scale fisheries sectors. Nevertheless, recent initiatives involving participatory approaches to research and management show potential to improve compliance with several principles. Two weaknesses of using Ostrom's principles for the analysis of the cases were a lack of attention to social learning and the exclusion of external drivers.

Keywords: Commons; Comanagement; Governance; Participation; Social learning; Social-ecological systems; Artisanal fisheries; Migration

Introduction

It is well known in the commons literature that resource users, such as small-scale fishers, are capable of managing their resources under certain circumstances (e.g., Ostrom 1990; Agrawal 2001; Dietz et al. 2002; Cinner et al. 2013; Ernst et al. 2013). Three kinds of "pure" property rights regimes – common property, private property, and state (or government) property – have all been associated with both success and failure, although top-down state property regimes are seldom associated with successful management (Feeny et al. 1990; Ostrom 2005). Over time, commons theory has sought new questions and approaches. Commons research has increasingly moved to considering commons as complex systems characterized by self-organization, non-linearity, uncertainty, and scale (Berkes et al. 2003; Berkes 2009). As well, there has been a shift in emphasis regarding scale, moving from local to multilevel approaches, including local, regional and global levels (Ostrom et al. 1999; Dietz et al. 2003).

Since the late 1980s, co-management, which is informed by commons theory, has been widely proposed as a partial solution to resource crises and conflicts (e.g., Jentoft et al. 1998; Gutiérrez et al. 2011). As a management regime that bridges community and government levels (Wilson et al. 2003), co-management can be understood as a type of property rights regime, combining elements of common property and state property, but can also be seen as an institutional design that considers the sharing of costs and benefits. Co-management was initially conceived as a power-sharing arrangement between the state and a community of resource users (e.g., Pinkerton 1989; Pomeroy and Berkes 1997). However, it has been evolving over time; the concept has become more complex, recognizing the existence of multiple stakeholders with multiple relationships, as documented for example for the Chilean coastal benthic co-management system (Marín and Berkes 2010). In addition, co-management has increasingly been understood as a problem solving process, often long and continuous, rather than an endpoint (Carlsson and Berkes 2005).

Furthermore, co-management needs to incorporate a learning-by-doing component, becoming adaptive co-management over time (Armitage et al. 2007, 2008). Often seen as a natural evolution of co-management (Olsson et al. 2004), adaptive co-management combines the dynamic learning characteristic of adaptive management (experimental and experiential) with the linking characteristic of co-management, vertically and horizontally (Plummer et al. 2012). Key features of adaptive co-management include a focus on integrating different knowledge systems, collaboration and power sharing among community, regional, and national levels, and management flexibility (Olsson et al. 2004). Adaptive co-management becomes particularly suitable for managing complex social-ecological systems that include human and biophysical subsystems in a two-way feedback relationship (Berkes 2011). It is also suitable to deal with wicked problems, such as fisheries and coastal governance (Jentoft and Chuenpagdee 2009), because these require participatory approaches with interaction, deliberation and social learning (Schusler et al. 2003) involving community and government stakeholders.

There is a vast literature specifying the conditions that would promote the sustainable management of the commons (e.g., Ostrom 1990; Agrawal 2001), successful co-management (e.g., Pomeroy 2007; Evans et al. 2011; Cinner et al. 2012), and adaptive co-management (e.g., Armitage et al. 2009). However, most authors would probably agree that these conditions are situation-specific, because adaptive co-management itself depends on the context (Armitage et al. 2009). Ostrom's (1990) eight design principles are remarkable in the scholarly literature about commons sustainability and collective action because they capture some of the commonalities regarding the necessary conditions. These principles have been used to evaluate and diagnose various resource systems, including fisheries (e.g., Pinkerton and Weinstein 1995; Gelcich et al. 2006; Yandle 2008; Arias Schreiber and Halliday 2013; McClanahan et al. 2013; Fleischman et al. 2014; Galappaththi and Berkes 2015), and some are among the necessary conditions for co-management and adaptive co-management (e.g., Pomeroy 2007; Armitage et al. 2009). Cox et al. (2010) analyzed 91 of these studies and concluded that Ostrom's eight principles were well supported empirically, but suggested splitting three of them, in line with the evidence from the cases.

This research is based on two coastal artisanal or small-scale fisheries, one in Piriápolis (Río de la Plata, Uruguay) and the other in Praia Grande/Ilha do

Araújo (Paraty, Brazil). Small-scale fisheries are known to be important ecologically, economically and socially in Uruguay and Brazil, as well as in South America in general (Begossi 2010; Salas et al. 2011). Nevertheless, government fishery development policies in both countries have focused almost exclusively on large-scale fisheries (Diegues 2006; Galli 2008; Puig et al. 2010). Small-scale fisheries in coastal Uruguay and Brazil have been experiencing a social-ecological crisis (Trimble 2013), which is alarming because of the numerous coastal communities they sustain. Catches have been declining (according to government's official data and fishers' observations), fishers are in need of additional sources of income, and the mismanagement of fisheries has led to a questioning of the top-down approach (Diegues 2006; Trimble and Johnson 2013; Begossi and Lopes 2014; Zurba and Trimble 2014). However, there are signs of progress. In both countries, government agencies in charge of fisheries management have shown willingness to devolve some power to user groups in order to increase compliance of rules through co-management, among other reasons (Seixas et al. 2009; Trimble 2013). As well, fishers are willing to become meaningfully involved in fisheries decision-making (Trimble and Johnson 2013).

Considering the positive outcomes of adaptive co-management, such as increased social-ecological resilience, enhanced efficiency and effectiveness of decision making, and community empowerment (Plummer et al. 2012), the objective of this research is to identify opportunities and barriers to adaptive co-management of small-scale fisheries in coastal Uruguay and Brazil using Ostrom's design principles for guidance. This is timely because of the ongoing transition from top-down management to participatory approaches to decision making in the study areas. In addition, we intend to contribute to the use of Ostrom's principles for diagnostic and prescriptive purposes in contexts where management regimes are being reformed. We do not intend, however, to conduct a pre- and post-assessment of the fisheries as this transition is in progress. In the next section we describe the research design, the study areas and the methods. In the results section we provide a snapshot analysis of the compliance with Ostrom's design principles as modified by Cox et al. (2010), and identify opportunities for improving the fit with the principles in the two fisheries. In the final section we discuss opportunities and barriers to adaptive co-management, as suggested by the analysis of the principles.

Methods

Research design and description of the case studies

This research was based on two case studies. The case study in Uruguay took place in the Piriápolis area, which comprises four landing sites (Pesquero Stella Maris, Piriápolis Port, Playa Hermosa and Playa Verde). The case study in Brazil was undertaken in two neighbouring communities in Paraty Municipality, Praia Grande and Ilha do Araújo (Fig. 1). Piriápolis is partly representative of small-scale fisheries locations on the Río de la Plata estuary, whereas Paraty is partly representative of Caiçara fishing communities of Southeastern Brazil. Fieldwork in Uruguay spanned 17 months (May–August 2010 and March 2011–March 2012),

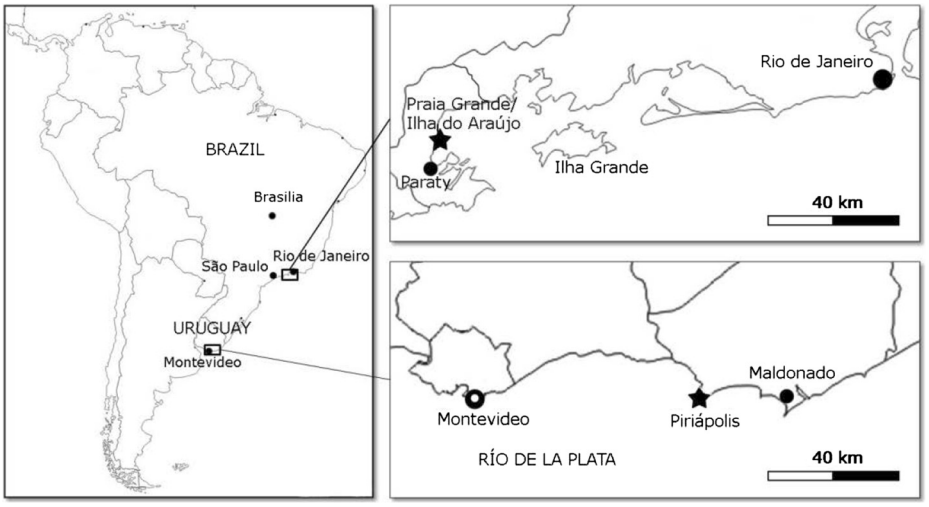

Fig. 1 Study areas: Piriápolis (Uruguay) and Praia Grande and Ilha do Araújo (Paraty, Brazil)

and lasted 4 months in Brazil (November 2010–January 2011 and April 2012). Fieldwork was longer in Uruguay because the research involved the facilitation of a participatory research project involving multiple fisheries stakeholders, investigating the role of this process in creating conditions for adaptive co-management (Trimble 2013; Trimble and Berkes 2013).

Piriápolis is a seaside city located in the external zone of the Río de la Plata (La Plata River), 98 km east of Montevideo, the capital city of Uruguay. About 10,000 people live in Piriápolis throughout the year, but this number increases through tourism to 40,000 during the austral summer. The number of artisanal or small-scale fishers and boats varies greatly throughout the year (e.g., from 30 to 150 fishers) and from year to year, mainly owing to resource availability. Many fishers are seasonally migratory: they move along the coast (either sailing or carrying their boats on a truck) primarily in response to whitemouth croaker (*Micropogonias furnieri*) movements. During the fieldwork period, the estimated number of fishing boats operating in each landing site varied as follows: 3–10 in Pesquero Stella Maris, 20–35 in Piriápolis port, 3–12 in Playa Hermosa, and 2–3 in Playa Verde. The majority of the fishing boats have a crew of three. The fishing gear most commonly used consists of bottom-set long-lines and gillnets of different mesh sizes. The three main species caught are the whitemouth croaker, the Brazilian codling (*Urophycis brasiliensis*), and the stripped weakfish (*Cynoscion guatupuca*). Most fishers sell their catch, entirely or partly, to fish buyers. Almost all of the Brazilian codling go to domestic markets, whereas the majority of the croaker and weakfish are exported (for details about catches and exports see DINARA 2014). Women generally do shore work related to fishing, such as preparing the long-lines and baiting the hooks, disentangling the fish from gillnets when the boats arrive at the port, and cleaning fish.

In Praia Grande and Ilha do Araújo, as in other communities of Paraty municipality (Rio de Janeiro State), small-scale fisheries are important for the local

economy (Begossi et al. 2010). Paraty has about 37,000 inhabitants and is a well-known tourist destination. It is located inside the Atlantic Forest region, between two of the largest urban centres in Brazil: Rio de Janeiro and São Paulo. Artisanal or small-scale fisheries have provided a source of both food and income for the Caiçaras, the local people who are descendants of Portuguese colonizers, native indigenous peoples, and African slaves (Diegues 2006). Caiçara livelihoods are composed of a mix of activities including fisheries, agriculture, and increasingly, tourism and the sale of non-timber forest products (Hanazaki et al. 2007, 2013). Fishers generally combine fishing with tourism, taking tourists aboard their boats, although fishing is the activity they prefer. They wish catches were not declining so that they could keep fishing in the future (Trimble and Johnson 2013).

The fishing tradition remains stronger in Ilha do Araújo, with an estimated number of 50 fishers from the 116 households of the village, compared to 25 in Praia Grande from 140 households. In both communities, fishers are generally canoe and/or boat owners and they mostly work on their own (i.e., one fisher per canoe or boat). Although canoes have been largely replaced by motorized boats, some fishers, especially the older ones, still use dugout canoes to go fishing. Fishing gear consists mostly of trawl nets and otter trawls for shrimp, gillnets of different mesh sizes for fish and shrimp, and to a lesser degree, bottom-set longlines. The main species caught are shrimp (*Xiphopenaeus kroyeri, Litopenaeus schmitti*), whitemouth croaker, weakfish (*Cynoscion spp.*) and common snook (*Centropomus undecimalis*). As in Piriápolis, most fishers sell their catch, entirely or partly, to fish buyers. However, the species caught are for domestic markets, not exports. Women generally work on shore, peeling shrimp, catching crabs, and gutting and filleting fish. Men and women working in the Piriápolis and Paraty fisheries tend to like their jobs, which they see as a way of life (Trimble and Johnson 2013). About 80 % of the terrestrial area of the Paraty Municipality and adjacent marine areas are occupied by protected areas. Tamoios Ecological Station (ESEC Tamoios) is a no-take protected area which was established by a government decree in 1990 with the aim of protection, research and monitoring the marine ecosystem of the Ilha Grande Bay, and its islands. The use of marine resources in the ESEC Tamoios is forbidden, resulting in conflicts between fishers and the agency in charge, the Chico Mendes Institute for Conservation of Biodiversity (ICMBio 2009). Fishers from Praia Grande and Ilha do Araújo fish inside and around the ESEC Tamoios.

According to Paraty and Piriápolis fishers, the trend of declining catches has become more noticeable since 1990–2000 and 2000–2005, respectively. Moreover, they stated that certain species have disappeared from the catch in both regions, leading to decreased catch diversity (Trimble 2013). In Uruguay and Brazil, fisheries are legally the property of the State. DINARA (The National Directorate of Aquatic Resources) within the Ministry of Livestock, Agriculture and Fisheries (MGAP) is the government agency in charge of management in Uruguay. However, several other agencies have responsibility over fishery-related issues. In Brazil, fisheries are managed by two government organizations: the Ministry of Fisheries and Aquaculture (MPA); and the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA, within the Ministry of Environment). The

Ministry of Fisheries is the coordinator of joint actions for the sustainable use of fisheries resources, whereas IBAMA is in charge of enforcement and management or protection of threatened species (Medeiros 2009). ICMBio is the agency in charge of federal protected areas in Brazil.

Data collection

A total of 64 respondents (55 men and 9 women) were interviewed, formally or informally, in Uruguay: 42 small-scale fishers (Piriápolis); 8 members of DINARA; 2 members of the Coast Guard; 1 member of the Port Authority; 1 member of the Municipal Government; 1 member of the national union of seamen (SUNTMA, representing mainly the large-scale fisheries sector); 2 fish buyers; 5 university researchers; and 2 members of NGOs. Meanwhile, in Brazil, formal and informal interviews were conducted with 32 respondents (22 men and 10 women): 30 small-scale fishers (15 from Praia Grande and 15 from Ilha do Araújo); 1 fish buyer; and the president of the fishers' municipal union (Colônia de Pescadores de Paraty). In both cases, fishers were selected purposively to maximize respondent diversity in terms of age, years of experience in the fishery, and gear used.

The main topics addressed in the interviews were as follows: (i) social-ecological changes that have been occurring in the fishery (e.g., Have there been changes in the species diversity, abundance, size? Have the fishing practices and fishing spots changed?); (ii) local and formal rules for resource use (e.g., How do you decide when to go fishing for what? Are there local norms and/or regulations? Who enforces and what are the sanctions when rules are violated?); (iii) social relationships among fishers (including social norms), between fishers and government agencies, and between government agencies (e.g., How is your relationship with [name of the stakeholder] in terms of trust, respect, solidarity, frequency and purpose of communication? Have those relationships changed over time?); and (iv) fisher participation in management (e.g., How are new regulations made? Should fishers participate in decision-making? Should local and scientific knowledge be combined or complemented?). Interviews were conducted in Spanish (Uruguay) and Portuguese (Brazil) by the lead author. Some interviews were audio-recorded and some were recorded by handwritten notes. Interviews and field notes were coded in their original language.

In the two study areas, participant observation was a complementary data collection procedure throughout the research. The researcher lived in the communities and participated in fishers' daily activities on land and at sea, taking descriptive and analytical field notes daily (Bernard 2006). Participant observation was also conducted during the following events: two informal meetings held at landing sites in Piriápolis, one formal meeting with fishers organized by the lead author at a municipal venue, and multistakeholder participatory research workshops in the same city; sessions of one council in Canelones (Río de la Plata coast) established by the government for artisanal fisheries co-management; one meeting of the community association of Praia Grande; and the first meeting organized by ICMBio to discuss an institutional arrangement called Commitment Terms in the ESEC Tamoios. Finally, document review was conducted to complement and validate data gathered through observational and conversational

methods. Reviewed documents consisted of fisheries regulations, meetings' reports, and new fisheries law in Uruguay.

Ostrom's design principles (as amended by Cox et al. 2010) did not guide the data collection process but were used as an analytic tool for the purpose of this paper. Table 1 shows the sources of data used to analyze each principle. Our objective was not to conduct an exhaustive analysis of the compliance with the design principles in the two small-scale fisheries but rather to discuss how the principles may shed light on the identification of opportunities and barriers to adaptive co-management (i.e., the main theoretical framework guiding the broader research).

Table 1 Ostrom's design principles (as amended by Cox et al. 2010) and sources of data to qualitatively analyze their compliance in the two case studies

Design principles (Ostrom 1990, Cox et al. 2010)	Definition (Cox et al. 2010)	Sources of data
1A. Clearly defined user boundaries	Clear boundaries between legitimate users and nonusers must be clearly defined	Interviews Participant observation Documents
1B. Clearly defined resource boundaries	Clear boundaries are present that define a resource system and separate it from the larger biophysical environment	Interviews Documents
2A. Congruence between rules and local conditions	Appropriation and provision rules are congruent with local social and environmental conditions	Interviews Participant observation Documents
2B. Proportional equivalence between costs (provision rules) and benefits (appropriation rules)	The benefits obtained by users from a common-pool resource (CPR), as determined by appropriation rules, are proportional to the amount of inputs required in the form of labor, material, or money, as determined by provision rules	Participant observation
3. Collective-choice arrangements	Most individuals affected by the operational rules can participate in modifying the operational rules	Participant observation
4A. Monitoring rule enforcement	Monitors who are accountable to the users monitor the appropriation and provision levels of the users	Interviews Participant observation
4B. Monitoring the resources	Monitors who are accountable to the users monitor the condition of the resource	Participant observation
5. Graduated sanctions	Appropriators who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and the context of the offense) by other appropriators, by officials accountable to the appropriators, or by both	Interviews Participant observation
6. Conflict-resolution mechanisms	Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials	Interviews Participant observation
7. Minimal recognition of rights to organize	The rights of appropriators to devise their own institutions are not challenged by external governmental authorities	Participant observation
8. Nested enterprises	Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises	Interviews Participant observation Documents

Results: analyzing the fisheries with the aid of Ostrom's design principles

In this section, we analyze whether the fisheries in Piriápolis and Paraty comply with Ostrom's design principles, indicating if conditions for collective action are met (Table 2). First, we look at the principles which are not achieved, and second, we focus on those which are partially achieved. Given the many similarities between the two cases, findings are presented jointly and not in separate sections. Attention is given to the changes that the fisheries have experienced as social-ecological systems. Finally, we analyze opportunities for increasing compliance with the design principles.

Unfulfilled principles in the Piriápolis and Paraty fisheries

Principle 1B states that a resource system should have well-defined boundaries, separating it from the larger biophysical environment. These boundaries help internalize the positive and negative externalities originating from resource use (Ostrom 1990; Cox et al. 2010). The main fishing resources in the two study areas are broadly distributed and hence the conditions do not comply with Principle 1B. For instance, the white-mouth croaker is widely distributed along the western coast of the Atlantic Ocean, from Mexico to Argentina. The species distribution is continuous from Southeastern Brazil to Argentina, and the Río de la Plata estuary is an important spawning area (Vasconcellos and Haimovici 2006). Although Principle 1B applies to fishing resources (e.g., Gelcich et al. 2006; Ernst et al. 2013), in many cases, unclear boundaries of mobile fishing resources are the rule rather than the exception (e.g., Pinkerton and Weinstein 1995; Fleischman et al. 2014).

According to Principle 2B, the benefits obtained by users from a commons, via their participation in collective action, as determined by appropriation rules, should be proportional to inputs in the form of labour, material, or money, as determined by provision rules (Ostrom 1990; Cox et al. 2010). In both study areas, given the prevailing lack of restrictions on fishing effort (e.g., gillnet and long-line length), boat owners with higher financial capital are free to increase their fishing effort and make more profit. Fishers who own smaller boats and/or those who operate with less fishing gear are critical of the larger operators and are concerned about overfishing. In fact, many fishers in coastal Uruguay are concerned that the small-scale fishery

Table 2 Fulfillment of Ostrom's design principles in the Piriápolis (Uruguay) and Paraty (Brazil) small-scale fisheries

Design principles (Ostrom 1990, Cox et al. 2010)	Piriápolis	Paraty
1A. Clearly defined user boundaries	Partially	Partially
1B. Clearly defined resource boundaries	No	No
2A. Congruence between rules and local conditions	Partially	Partially
2B. Proportional equivalence between costs (provision rules) and benefits (appropriation rules)	No	No
3. Collective-choice arrangements	Partially	Partially
4A. Monitoring rule enforcement	Partially	Partially
4B. Monitoring the resources	Partially	Partially
5. Graduated sanctions	Partially	Partially
6. Conflict-resolution mechanisms	No	No
7. Minimal recognition of rights to organize	Partially	Partially
8. Nested enterprises	No	No

is tending to become larger and larger. The proportional relationship between investment and catches in the two cases is not a consequence of collective action but rather of the lack of clear appropriation and provision rules regarding fishing effort, thus violating Principle 2B.

Conflicts over the commons are inevitable, and thus low-cost conflict-resolution mechanisms (Principle 6), both among resource users and between users and officials, are important for collective action (Cox et al. 2010). In Piriápolis and Paraty, there are numerous conflicts between fishers and government agencies, as well as within and between user groups, between small- and large-scale fishers, between small-scale fishers using different gear, and between small-scale and sport fishers. In addition, government agencies involved in fisheries management lack coordination in the two study areas (Trimble 2013). However, there are no arenas for addressing and resolving these conflicts.

Nested enterprises (Principle 8) are also lacking. This principle establishes that appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in a hierarchy of levels. Given the multiple scales of fishing resources in Piriápolis and Paraty, nesting the smaller systems in the larger ones may be necessary as institutional nesting can help accomplish the match between the user and the resource boundaries (Cox et al. 2010; Fleischman et al. 2014).

Principles partially satisfied in Piriápolis and Paraty

User boundaries

Clear boundaries between legitimate users and nonusers are important for collective action (Principle 1A), and this is inevitably related to resource boundaries (Ostrom 1990; Cox et al. 2010). Both in Uruguay and Brazil, the large-scale fishery exploits many of the same species (e.g. croaker) as the small-scale fishery. In Uruguay, fishers and non-fisher stakeholders claimed that coastal bottom-pair-trawling, the main fishing technique used by the large-scale sector, was the major cause of resource decline. In Paraty, fishers stated that the main causes of resource decline were bottom-trawling by both small and large-scale fishers, encircling gillnet for snook by small-scale fishers, and purse-seining by large-scale boats called *traineiras*.

"Legitimate users" are those who have a valid fishing license issued by DINARA (Uruguay) or the Ministry of Fisheries and Aquaculture (Brazil). In Brazil, small-scale fishing licenses do not determine boundaries for fishing activities, except that boats cannot operate inside no-take protected areas (e.g., ESEC Tamoios). Fishers in the Municipality of Paraty usually fish close to their community, and there is some informal division of fishing locations, although there is shared use of many other locations by fishers from different communities, such as Praia Grande and Tarituba (Begossi et al. 2012).

In Uruguay, DINARA passed a regulation in 2002 establishing the boundaries of four marine-coastal Artisanal Fishing Zones in the Río de la Plata and Atlantic Ocean, and in 2004 established three additional "overlap zones" (Fig. 2). One of the goals of this regulation was to facilitate fisher mobility within their zone. Prior to this regulation, fishers had to obtain DINARA authorization every time they wanted to depart from a landing site different from the one at which they were licensed. As Fig. 2 shows, each zone contains many fish landing sites; Piriápolis is located in Zone E. Fishers migrate within and sometimes between zones. Fishers may have authorization in the adjacent "overlap zone" of their assigned zone. Some also cross zone boundaries taking advantage of weak enforcement of fishing regulations. Most Piriápolis fishers, similar to

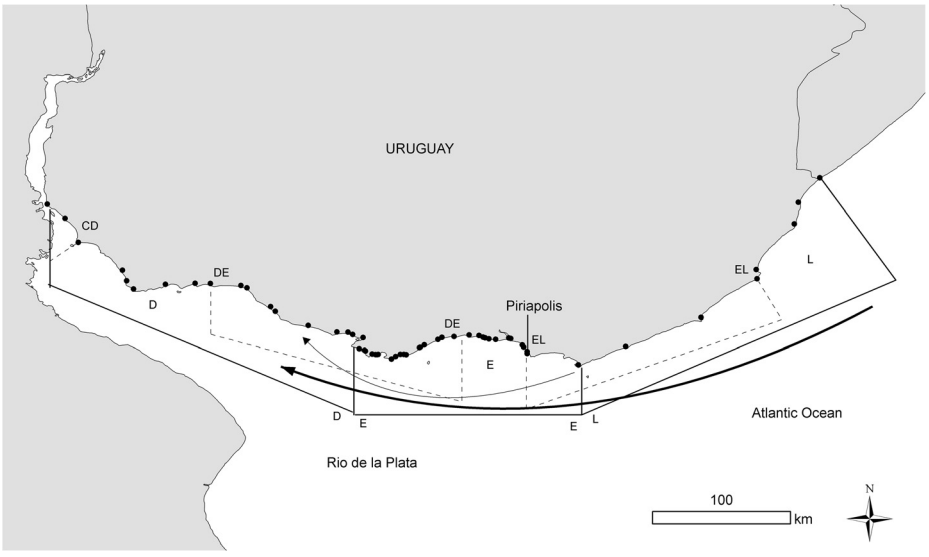

Fig. 2 Small-scale fishing zones in coastal Uruguay (as determined by DINARA) showing seasonal movements of fish and fishers (as relevant to Principles 1A and 1B). The dots along the coast show the location of fishing communities and/or landing sites of small-scale fishers. The solid lines show fishing zones D, E and L (zone K - comprising coastal lagoons - is not shown). The dashed lines show the overlap zones CD, DE and EL. The thick line with arrow denotes croaker movements (June–September), and the thin line with arrow indicates fisher movements in parallel with croaker migrations. The offshore boundaries of the zones are not necessarily to scale

fishers from other coastal localities in Uruguay, argue that mobility is necessary because fish migrate and the fishers could not make a living if they could not follow the fish. These fishers argue that "Uruguay is for Uruguayans", meaning they should be allowed to fish along the entire coastline. Nonetheless, the majority of the fishers consider that poorly organized mobility of fishing boats can be chaotic creating a concentration of too many boats in a small area.

Numerous changes have been occurring in the two fisheries, affecting compliance with this principle. Due to catch decline and the uncertainties associated with the increased unpredictability of the fishing activity, fishers have increasingly needed to look for alternative or additional sources of income. In the case of Piriápolis, this trend is particularly strong for fishers who decide not to migrate seasonally. At both sites, fishers have been noticing changes related to climate, such as increased unpredictability of weather conditions, unclear definition of the four seasons, and shifting wind patterns. These environmental changes have affected the occurrence of certain fish species (e.g., croaker, snook), making it more difficult to predict the beginning of fishing seasons (*zafras*: periods in which a certain species is caught in abundance). For instance, the croaker season in Piriápolis used to last three months in winter, whereas now it lasts less than a month. This has led fishers to move seasonally from Piriápolis to other localities where the croaker season is still on. Fishers' movements along the coast of Uruguay have changed over time. They are not as predictable as in the early 2000s, when the usual pattern was that fishers moved from Montevideo to Canelones during the fall and winter, and during the spring and early summer they concentrated in the area near Montevideo where the croaker spawns. Piriápolis fishers were not migrating in 1995 but now many are. Since 2006, they have increasingly migrated seasonally to the west, following the croaker. In Paraty, fishers do not migrate to other localities

following the fish, but their work is seasonal: during the summer, most fishers alternate fishing with tourism activities, in contrast with the winter when fishing is conducted full-time.

Local rules and social norms: congruence, collective choice, and rights

This section addresses three other principles (2A, 3 and 7) that are partially satisfied. The congruence between appropriation/provision rules and social-environmental conditions (Principle 2A) contributes to sustainable resource use and collective action. In Piriápolis and Paraty, there was some congruence between local rules and conditions. In both areas there was a local rule of first comer's rights. Once fishers set their gillnets, other fishers are expected to give them enough space so as not to cut off their fish supply. The actual distance between gillnets may vary according to season and to availability of fish. During the croaker season in Piriápolis and the snook season in Paraty, when resources are abundant, the distance between gillnets is relatively short. Also related to congruence, non-fishing days (such as Virgin's day -Yemanjá, Good Friday, and All Souls Day) were usually respected in both study areas, especially by Catholic fishers, but not by Evangelicals in Paraty. However, if fishers were going through hard times (i.e., poor catch) they could go fishing on those days without sanction. Furthermore, when selling opportunities were scarce, in one of the landing sites in Piriápolis, fishers would sometimes take turns going fishing and/or doubling the crew to six fishers instead of three, so that they could spread the benefits and all make some money.

Non-congruence between formal rules imposed by the government and local social-environmental conditions seemed to be common in both areas. In Uruguay, for example, a no-take zone for gillnets and long-lines within 300 m off the shoreline was created by DINARA, supposedly to protect spawning and nursery areas. The zone also functions to prevent conflicts between small-scale fishing and "nautical activities" such as recreational fishing. After coastal small-scale fishers mobilized to protest that this regulation affected their livelihoods, the no-take zone became effective only through the summer, which is high tourist season. In Paraty, the shrimp closed-season (March to May) is an example of internal-external incongruence. Fishers stated that the closed season should be earlier in the year because otherwise it leads to the harvest of undersized shrimp (see Trimble et al. 2014). These are examples of negative consequences on fishers and resources when externally imposed rules do not match local practices and environmental conditions.

The collective-choice principle (3) proposes that individuals affected by the operational rules should be able to participate in making and modifying those rules. In Piriápolis and Paraty, there were some local rules, as well as trust, solidarity and reciprocity norms among fishers, such as helping others in need at sea, sharing fish, and exchanging information (Trimble 2013). However, there were no collective-choice arrangements to limit fishing effort. This can be explained partly in terms of fishers' powerlessness in a context in which the large-scale fishery harvests much the same resources, with considerably higher catches. The lack of collective-choice arrangements to limit effort is also associated with weak organizational capacity among fishers, a consequence of lack of unity according to fishers from both areas. In Piriápolis, there was no fisher organization; in Paraty, even though there were community organizations ("residents' and fishers' associations"), fishery issues were seldom addressed in meetings and fishers rarely attended them.

Changes in fishing resources have had an impact on the relationships among fishers. Fishers from both areas stated that competition among them has increased, and social norms are now less respected, partly as a consequence of resource decline. For instance, stealing fish and fishing gear, and lying about fishing spots, are now more common in both Piriápolis and Paraty. At the latter site, fishers also commented that fish exchange is less frequent than in the past, although it still occurs. Nonetheless, resources decline was not the only factor leading to weakened relationships among fishers. Fishers' migration to Piriápolis from other localities was another major reason given by fishers to explain weakened social codes and principles in the fishery, whereas in Paraty, fishers referred to the negative impacts of increased tourism on social relationships within their communities after the construction of the coastal highway BR-101 linking the area to big cities (see also Oliveira and Berkes 2014).

Fishers from both Piriápolis and Paraty recognized that more unity among them is needed to improve the fishery. Nevertheless, they identified a number of barriers to getting together and working collectively, partially related to: (i) competition for bigger catches; (ii) differing interests between fishers who make their living exclusively from the fishery and those with additional sources of income; (iii) differing interests between fishers with low or high investment in boats and fishing gear; and (iv) fishers' relationship with fish buyers. Some fishers would like to form an association or cooperative to sell their catch directly to consumers, whereas others do not want to take any action that could be seen as opposing fish buyers. Fishers' dependence on fish buyers, who provide fuel, ice, bait, and money advances, could thus be considered an example of an external factor influencing the emergence of collective action.

Principle 7 relates to others discussed in this section, positing that government agencies respect the right of local users to create their own institutions. This principle is partially fulfilled in both study areas, but not fully because externally imposed rules are incongruent with local conditions (Principle 2A). In other words, fishers have the right to define their local rules as long as they obey the formal rules determined by the government, which leads to conflict-laden relationships between fishers and government.

Monitoring and sanctions

Monitoring compliance of rules and the condition of resources (Principles 4A and 4B), as well as assessing graduated sanctions when rules are violated (Principle 5), are three other principles leading to collective action. In Piriápolis and Paraty, fishers conduct informal monitoring of resources, but their long-term observations about the resources rarely reach the government agencies in charge of monitoring and decision making, a consequence of the prevailing top-down approach. Fishers from the two areas also monitor compliance, but when it comes to formal rules (e.g., fishing licenses, closed seasons), they expect the government to enforce and take action; rule enforcement is meant to be a government task. Fishers do not report law breaking by other small-scale fishers, they would only report large-scale fishing boats. Moreover, in the Piriápolis case, one local norm is that fishers must inform others if the Coast Guard or DINARA is carrying out enforcement in the area. Sanctions imposed by the government in the two areas (e.g., by DINARA, IBAMA, Coast Guard) include fines and fishing suspensions. Nevertheless, fishers may successfully negotiate with the officers to have the fines waived without resorting to bribery.

When local rules are violated, informal sanctions usually follow. However, these are neither graduated nor collectively established. Sanctions vary according to the rule and according to the person involved (i.e., different fishers might decide to take different actions, if any). Sanctions include scolding, decreased information exchange about fishing spots, and decreased fish exchange, among others. In Piriápolis, for example, after one crew member robbed a box of fish, nobody would take him fishing for many weeks, another form of punishment. Even though there are local sanctions, fishers wished there were government sanctions, such as fines, when stealing occurs.

Opportunities for improving compliance with Ostrom's design principles

Except for resource boundaries (Principle 1B), which logically cannot be changed, the fulfillment of the remaining principles can potentially be improved. Here we argue using three lines of evidence that this could be done through participatory approaches. First, a multi-stakeholder participatory research initiative developed in Piriápolis since 2011 to address local problems within the fishery sector provided opportunities for improving compliance with some of the principles. Fifteen participants from four stakeholder groups (seven fishers, one artisanal fisheries manager from DINARA, five university researchers, and two NGO representatives) were committed to this participatory research process and formed the group called POPA - *Por la Pesca Artesanal en Piriápolis*. The analysis of the contributions of this initiative to future co-management in the area (Trimble and Berkes 2013), as well as the evaluation of the participatory research process and outcomes (Trimble and Lázaro 2014), suggest that POPA provided an arena for conflict resolution between fishers and DINARA (Principle 6). It also contributed to improved collective-choice arrangements by increasing fishers' unity (Principle 3).

Second, the new fisheries law in Uruguay (N°19.175, passed in December 2013), which includes articles about stakeholder participation, provides a "window of opportunity" (Gelcich et al. 2010) for alternative management approaches. A national advisory board, the Fisheries Consultative Council, will be formed by representatives of DINARA, additional ministries (Defense; Foreign Affairs; Ministry of Housing, Planning and Environment), owners of industrial fishing boats, artisanal fishers, companies dedicated to the transformation of fish products, and the fisheries labour sector. Regional and local advisory boards for consultative co-management of artisanal fisheries (named "Fisheries Zonal Councils" in the law) have been established in some areas since 2012. They are integrated by representatives of DINARA, local and departmental governments, Coast Guard, and artisanal fishers. Both types of boards can potentially function to resolve conflicts (Principle 6). They can also contribute to building nested enterprises if horizontal and vertical linkages influencing governance decisions are established (Principle 8). In particular, the national board could provide the opportunity for addressing conflicts between the small- and the large-scale fishing sectors (Principle 1A). Furthermore, the implementation of zonal or local boards, which requires that fishers elect legitimate representatives, could contribute to collective-choice arrangements if fishers' organizational capacity is improved (Principle 3), perhaps by the help of external stakeholders (e.g., government, university, NGOs). Nonetheless, the different boards created by the new legislation will face numerous challenges due to

their multi-stakeholder nature (e.g., differing interests of the parties) and the anticipated low degree of power sharing (Trimble 2013), among others.

Third, government agencies responsible for fisheries and environmental management in Brazil have included participatory guidelines and frameworks in legislation. Promising approaches include Fishing Agreements, and deliberative management councils of two types of sustainable-use protected areas: Extractive Reserves and Sustainable Development Reserves (Seixas et al. 2009). In our study region in Brazil, an opportunity for fisher participation in management emerged in 2012, when the Consultative Council of the ESEC Tamoios started a process towards building the Commitment Terms (*Termos de Compromisso*) between the protected area and fishers from Tarituba (Paraty Municipality) (Trimble et al. 2014). Commitment Terms are an institutional mechanism which was formalized by legislation in 2012, to deal with issues of access and use of natural resources by local/traditional communities inside no-take protected areas. The Commitment Terms can potentially contribute to: reducing conflicts between fishers and ICMBio (Principle 6); increasing congruence between local and formal rules (Principle 2A); and favouring the emergence of collective-choice arrangements among fishers (Principle 3). Nonetheless, there are risks that the Commitment Terms might lead to conflicts between the fishers who will gain access to fish inside the ESEC Tamoios and those who will have to remain outside (Principle 1A). Furthermore, it has been claimed that Commitment Terms do not ensure fisher autonomy in decision making (Araujo et al. 2014), which may weaken Principle 6. Also, Commitment Terms are largely influenced by both the institutional context of the protected areas and the negotiation with the managers at the time (Araujo et al. 2014).

Discussion and conclusions

Ostrom's design principles are about collective action and how users can manage common-pool resources (Ostrom 1990). Can they also be used to guide policies towards adaptive co- management? Our analysis using two examples from Uruguay and Brazil indicates that the design principles help assess cases and provide guidance in the transition from top-down management to adaptive co-management, although with some limitations, as discussed below. Table 3 summarizes the major opportunities and barriers to adaptive co-management of small-scale fisheries in coastal Uruguay and Brazil. Some of the headings of Ostrom's (2009) multilevel, nested framework for analyzing outcomes achieved in social-ecological systems were used for illustrative purposes to organize the presentation of our findings. In what follows we discuss the main challenges for the transition towards adaptive co-management and we then discuss the connections between Ostrom's design principles and the analysis of opportunities and barriers to adaptive co-management.

Challenges for the transition towards adaptive co-management

Many of the barriers to adaptive co-management of small-scale fisheries in Piriápolis-Uruguay and Paraty-Brazil (Table 3) are complex and concern resource users and the governance system, indicating the need for institutional arrangements involving stakeholders at multiple levels (as shown in Section 4.3). Given that adaptive co-

Table 3 Opportunities and barriers to small-scale fisheries adaptive co-management in Piriápolis-Uruguay (UR) and Paraty-Brazil (BR)

Opportunities	Barriers
Resource system (Principles 1B, 4B)	
- (UR/BR) Resource crisis may lead to management changes	- (UR/BR) Catch declines
	- (UR/BR) Unclear resource boundaries
Resource users (Principles 1A, 2B, 3)	
- (UR/BR) Social norms	- (UR) Fishers' seasonal migration
- (BR) Clear group boundaries	- (UR/BR) Weak organizational capacities; limited collective-choice arrangements
- (UR) Fishers' capacity to act collectively when facing crises	- (UR/BR) Weakened relationships among fishers
	- (UR/BR) Conflicts with large-scale fisheries
Governance system (Principles 2A, 4A, 5, 6, 7, 8)	
- (UR/BR) Fishers' interest in co-management	- (UR/BR) Prevailing top-down management
- (UR) New fisheries law supporting the creation of multi-stakeholder boards or councils	- (UR/BR) Conflicts between fishers and management agencies
- (UR) Potential of participatory research involving multiple stakeholders	- (UR/BR) Weak coordination among government agencies
- (BR) Growing initiatives for fisher participation in protected area management	- (UR/BR) Weak government rule enforcement
	- (UR/BR) Poor capacity of stakeholders regarding co-management

Ostrom's design principles related to each of the three categories (resource system, resource users and governance system) are shown in parenthesis

management can be a risk-sharing mechanism (Armitage et al. 2009), it can be argued that the higher the uncertainty of the resource system, the greater the need for participatory approaches to research and management.

In some situations, a barrier (catch declines) can also act as an opportunity (a resource crisis triggering policy change), as seen for example in the reorganization of Chilean coastal fisheries (Gelcich et al. 2010). Although not shown as an opportunity in Table 3, conflicts among stakeholder groups are a triggering factor for co-management (e.g., Pomeroy and Berkes 1997; Plummer and FitzGibbon 2004), but also a challenge for the process (e.g., Napier et al. 2005; Pomeroy 2007; Armitage et al. 2009). In fact, conflicts of interests among those involved, power asymmetries, and insufficient resources (financial, human, technical, etc.) are among the main factors contributing to the failure of adaptive co-management, as shown in a recent literature review (Plummer et al. 2012). One major barrier emerging from our research which did not arise in that review and has received little attention in the literature is fishers' migration (Nunan et al. 2012).

Fishers' seasonal migration is a major issue in the Uruguay case. Clearly defined boundaries is one of the principles for collective action (Ostrom 1990), and a condition for adaptive co-management (Armitage et al. 2009). However, in many cases fishers are mobile. Seasonal migration among fishers, which is common in numerous countries (e.g., Aburto et al. 2009; Njock and Westlund 2010; Crona and Rosendo 2011), has implications for co-management. For example, Crona and Rosendo (2011) argued that migration can either motivate local co-management participation as a means of excluding outsiders, or it can undermine co-management because of the increased

heterogeneity of resource users, disrupting clearly defined boundaries. Tackling issues related to fishers' migration requires the collaboration of the different stakeholders involved. This could be done through the adaptive co-management process. In the Uruguay example, fishers stated that the mobility of fishing boats should be better organized. Migrant fishers should be thus included in decision-making processes as a distinct user-group. However, given that migrants may be competing for resources with host communities, they sometimes suffer from discrimination, marginalization and exclusion from various aspects of community life, including political institutions and decision-making (Njock and Westlund 2010; Crona and Rosendo 2011; Nunan et al. 2012).

Linking Ostrom's design principles and adaptive co-management: gaps and opportunities

The assessment of Ostrom's design principles in our two cases assisted in the identification of barriers to adaptive comanagement of small-scale fisheries, and also opportunities for moving in that direction. In fact, there is some congruence between the design principles and the factors contributing to the success of adaptive co-management as per the recent literature (Plummer et al. 2012). For example, government control over illegal resource use, one of these factors, relates to Principle 4A (Monitoring rule enforcement), whereas social networks and participation of all relevant stakeholders in management, two other factors contributing to success of adaptive co-management (Plummer et al. 2012) fit within Principle 8 (Nested enterprises).

Nonetheless, social learning, a main component of adaptive co-management, and a factor contributing to success (Plummer et al. 2012), was not visible when assessing Ostrom's principles. Incorporating learning as an attribute of Ostrom's social-ecological system framework has been difficult (Basurto et al. 2013). Adaptive co-management needs feedback learning or social learning over time; this remains as a challenge for Ostrom's diagnostic approach.

Furthermore, scale issues were another challenge of using Ostrom's design principles towards adaptive co-management. The temporal dimension of scale requires an accounting for the fact that social-ecological systems are changing fast, as seen in our two cases. A single analysis of the principles would only give a snapshot. Therefore, principles should be analyzed over time, and the principles should be made or treated as dynamic, in the manner of Gelcich et al. (2006); Yandle (2008) and Arias Schreiber and Halliday (2013), who analyzed the principles at two time periods. In our case studies, we attempted to do this by analyzing trends in social-ecological change when assessing the principles, and by illustrating the importance of changes by pointing out that the formation of the POPA group and its participatory research initiative (Trimble and Berkes 2013) made a difference in meeting at least two design principles.

Our analysis of the two cases suggests that compliance with all of the principles, except Principle 1B relating to resource boundaries, can potentially be improved through policy interventions. In particular, adaptive co-management becomes an attractive approach to overcome challenges in the long run, increasing compliance with the principles, because there is evidence that this governance approach leads to improved access to resources, increased equity in distribution of costs and benefits, resolution of conflicts, enhanced communication and negotiation, development of networks, and enhanced efficiency and effectiveness of management (Plummer et al. 2012). However, adaptive co-management, by itself, is no guarantee of sustainable resource use, social-ecological resilience or pluralism

(Plummer et al. 2012). In Chile, for instance, a government-led fisheries co-management policy weakened traditional institutions for certain resources, reducing compliance with some of the principles (Gelcich et al. 2006). Future research may investigate how co-management initiatives led by the government in Uruguay and Brazil shift to adaptive co-management over time, what adaptive co-management outcomes are produced and how (Plummer et al. 2012, 2014), and how compliance with Ostrom's principles is improved. Similarly, the design principles could be applied to the multi-stakeholder boards implemented in Uruguay given that it has been argued that the principles can be adopted as a practical guide for improving the efficacy of different kinds of groups (e.g., governments, businesses, neighborhoods) (Wilson et al. 2013).

The scale issue also comes up when considering the impact of large-scale fisheries on small-scale fisheries. In both study areas, the two kinds of fisheries essentially target the same mix of species, and the adverse impact of large-scale fisheries is documented (Defeo et al. 2009; Begossi et al. 2010). To the extent that external impacts and drivers can be considered a kind of scale issue, competing uses of the coastal zone also fall into this category. For example, the zoning for recreation and leisure impacts the Piriápolis fishery as discussed above, and zoning for protected areas impacts the Paraty fishery (Begossi et al. 2010). On the other hand, Paraty fishers make a major part of their livelihood from tourism (Hanazaki et al. 2013), so these impacts are not always negative.

As noted by Cox et al. (2010), Ostrom's principles do not directly take into account external factors; the principles are essentially about internal factors leading to successful collective action. Hence, the principles need to be supplemented by an analysis of external drivers such as imports of cheap fish and croaker exports in the case of Piriápolis. Climate change impacts and government policies favouring large-scale fisheries over small-scale ones may also fall in this category. In general, global environmental change, globalized markets and technological changes all have major impacts on commons management (Berkes 2009; Berkes 2011). Therefore, a complex adaptive systems view would imply that commons and adaptive co-management research should give more attention to external variables and drivers (Cox et al. 2010). Individuals or companies using the same resources as local people but at a different scale represent an additional, and often ignored external variable affecting adaptive co-management.

To conclude, Ostrom's design principles contributed to the identification of opportunities and barriers to transitioning towards adaptive co-management of small-scale fisheries in coastal Uruguay and Brazil, where top-down management is still the prevailing approach. However, there are weaknesses of using Ostrom's principles for this purpose, such as a lack of attention to social learning and the exclusion of external drivers. Nevertheless, our research, which represents the first analysis of these two small-scale fisheries from a commons point of view, suggests that Ostrom's principles can be used as a diagnostic and prescriptive approach for policy in contexts where governments intend to transition to co-management, such as in Uruguay, Brazil, and perhaps other countries. Another contribution of our analysis is that it suggests that participatory processes that bring together different stakeholders at multiple levels can help reduce conflicts among them and build nested governance, increasing compliance with the principles and social-ecological sustainability.

Abbreviations

DINARA: National Directorate of Aquatic Resources (national fisheries agency of Uruguay); ESEC: Ecological Station (a category of no-take protected areas in Brazil); ICMBio: Chico Mendes Institute for Conservation of Biodiversity (Brazil's

federal agency in charge of protected areas); IBAMA: Brazilian Institute of Environment and Renewable Natural Resources; MGAP: Ministry of Livestock, Agriculture and Fisheries (Uruguay).

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
Both authors participated in the design of the research, analysis of the findings and crafting of the manuscript. MT carried out the fieldwork. Both authors read and approved the final manuscript.

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Managing small-scale fisheries in Colombia

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Abstract

The small-scale fishermen of Colombia face a wide range of problems and conflicts. While many problems are shared among individuals from both the Atlantic and the Pacific coasts (bi-coastal), others are unique to a subset of the communities, only occur on one of the coasts (uni-coastal) or in an individual locality. To come to grips with the major problems for these fisheries requires establishing a fisheries management strategy that can prioritize solutions at different levels: national, coastal, and local. This study describes the solutions identified by three sets of stakeholders: fishermen, local leaders and fisheries experts, to improve small-scale fisheries management in Colombia. Some cross-cutting solutions were recommended by all three sets of stakeholders. In other cases, only two of the three stakeholder groups agreed on certain proposals, and some isolated solutions were found in only one type of stakeholder. All three sets of stakeholders recommended that the government put in place fundamental regulatory framework for small-scale fisheries including support for alternative employment opportunities to reduce fishing pressure on the resources. Some but not all groups supported specific measures, such as gear restrictions, closed areas and closed seasons. There was also a clear need to distinguish those truly engaged in fishing as their livelihood from opportunists moving in and out of the sector. Specific recommendations are here presented to reform and restructure governance through co-management, and to develop a consensus among the main government and user stakeholders.

Keywords: Colombia, Small scale fisheries, Co-management, Fishery solutions

Introduction

Small-scale tropical fisheries studies in the last few decades have strongly benefitted from a multidisciplinary approach that includes ecological, economic, sociological, technological and governance information (Christy 1997; Preikshot and Pauly 1998). Many fisheries frameworks and governance models around the world are based on a combination of government and community efforts. These models could be used as points of departure for discussions with important stakeholders in Colombian small-scale fisheries.

A growing global literature describes lessons learned from implementing small-scale fisheries management (Berkes 2004, 2010; Brown and Pomeroy 1999; Chuenpagdaee and Jentoft 2007; Cinner et al. 2012; FAO 2006; Francis et al. 2007; Garcia and Cochrane 2005; Lam and Pauly 2010; Lebel et al. 2006; Olsson et al. 2004, 2006; Pomeroy et al. 2004; Salas et al. 2011; Tyler 2006). Understanding social interactions within the context of fishing, and the dynamic among fishermen within and among

fishing communities (St. Martin et al. 2007) are essential in order to develop effective management strategies.

Moreover, the theoretical context for co-management of small-scale fisheries is an ongoing debate among academics and fisheries management practioners, especially in the context of social-ecological systems (Berkes et al. 2001; Ostrom 1990, 2009; Pomeroy et al. 2004, 2011). Weak governance is one of the main causes of the present poor condition of fisheries and is characterized by (but are not limited to) corruption, lack of stakeholder participation, political will and capacity, weak institutional capacity and capabilities, poor enforcement, and inadequate information (CRC et al. 2006). Small-scale fisheries are extremely diverse, complex and dynamic (Berkes et al. 2001). They operate at many different scales and with many different stakeholders. These characteristics make the challenges and concerns that confront small-scale fisheries governance more difficult. Given the range of actors in small-scale fisheries, with their varying perceptions, agendas and power, there is a need to develop a governance system that can include multiple stakeholders (Bavinck et al. 2005). How best to tap their various interests, agendas and capacities remain a challenge.

In the case of Colombia, small-scale fishermen have not been fully recognized as key stakeholders in the fisheries management process (Cuello and Duarte 2010; García 2010; Saavedra-Díaz et al. 2015a). It is critically important to involve communities in co-management practices in order for management to be fully effective and to reduce the propensity for overexploitation. In the Caribbean and Latin America, examples of co-management exist in Mexico, Belize, Brazil, Peru and Chile. Due to the high diversity of the fisheries in these areas, as well as poverty, violence, forced displacement, among other situations, many co-management practices need to be implemented in concert in order to be effective. Also, decision makers need to recognize the importance of supporting management decisions with local knowledge (Begossi and Brown 2003). Recently, fisheries co-management was successfully implemented in Chile by dividing responsibilities for the Management Area System between government agencies and small-scale fishers' organizations (Marin and Berkes 2010). This success raised consciousness among fishermen. It avoided the tragedy of the commons by building rapport between the state and fishermen, raising ecological and management awareness, and promoting teamwork between fishermen and scientists (Schumman 2007). The research presented here explores possible cross-cutting solutions of this kind for the particular realities of the under-researched small-scale fisheries of Colombia.

Government institutions and agencies in Colombia have attempted to organize the fisheries sector and articulate policy through the publication of different sets of national documents. However, a disarticulated institutional framework and a thicket of contradictory policies highlight the fragmented nature of Colombian fisheries management. Unfortunately, national planning documents such as the "Colombian Vision 2019" have set unrealistic goals for increases by 30 % in fisheries captures for 2019 (ECOVERSA 2007). Development goals such as this misunderstand the current status of both fishery resources and the management system and have not directly involved local communities in the development and implementation of policy to achieve sustainable fisheries (Hart 2003; McCay and Jentoft 1996; Schumman 2007). The Colombian legal framework that regulates fishery resources at the national level is the Code of Renewable Natural Resources and Protected Environment, created by the Decree/law 2811 of 1974 and Law

13 that created the General Statute for Fisheries in 1990. The Rural Development and Agriculture Ministry- through the Fishery and Aquaculture National Authority - is in charge at the national level of the Marine Small-Scale Fishery sector since 2011. However, over the last decade five different institutions have been in charge of fisheries. Such institutional instability at the national level has being one of the major challenges for successful management of the small-scale fishery sector.

Another challenge to overcome is the difference of social perceptions among stakeholders –i.e., fishermen, local leaders, and fishing experts and their existing relationships within marine ecoregions. According to Saavedra-Díaz et al. (2015b), fishermen perceive destructive fishing methods as the most significant problem with the highest percentage response among all respondents (70 % in the Caribbean coast and 79 % in the Pacific), followed by the lack of regulation enforcement (60 % in Caribbean and 47 % in Pacific) and pollution and industrial contamination. Local leaders identified the low quality of life of fishermen including the lack of public services, lack of potable water and lack of education focused on environmental awareness. They also noted a weakness of fisher's organizations and leadership. In contrast, the majority of fisheries experts believed that the small-scale fishery sector has been largely ignored by governmental actions. The fisheries experts identified the instability of regulatory authorities and lack of control measures, oversight and monitoring by the agencies in charge of artisanal fishery activity due to lack of personnel, and the lack of infrastructure or equipment to facilitate this work. While many problems occur on both coasts, other problems are coastally unique, and further, some affect only a small portion of fishing communities. In consequence, there is a need to establish a fisheries management strategy that can prioritize solutions at different levels: national, coastal, and local.

Using results from the same survey discussed in Saavedra-Díaz et al. (2015b), the objective of this paper is to discuss the solutions identified by fishermen, local leaders and fisheries experts for improving small-scale fisheries management in Colombia. In addition, we present specific recommendations on a framework for small-scale fisheries governance in Colombia.

Methods

Study area

The Colombian coastline is divided between the Caribbean and the Pacific. The Caribbean coastline is 1642 km in length and the Pacific coastline is 2188 km in length. The Caribbean coast has a population of 2,919,348, while the Pacific coast has a population of 543,594 (Posada and Rozo 2005). Colombia has 12 political and administrative coastal states, eight on the Caribbean coast and four on the Pacific coast. Different from the states, coastal and marine environmental divisions separate the Colombian coast into six Coastal and Marine Ecoregions (CME) on the Caribbean and four CMEs on the Pacific coast (Fig. 1), plus four Insular Ecoregions on both oceans. CMEs are distinguished by different environmental characteristics such as geo-morphology, hydrography, sedimentology, and coastal and marine ecosystems (Posada and Rozo 2005). Nevertheless, state and CME boundaries are relatively similar, in some cases nearly overlapping. Since the present study focuses on environmental conditions, CMEs provide spatial orientation. Although the Caribbean and Pacific Insular Eco-regions

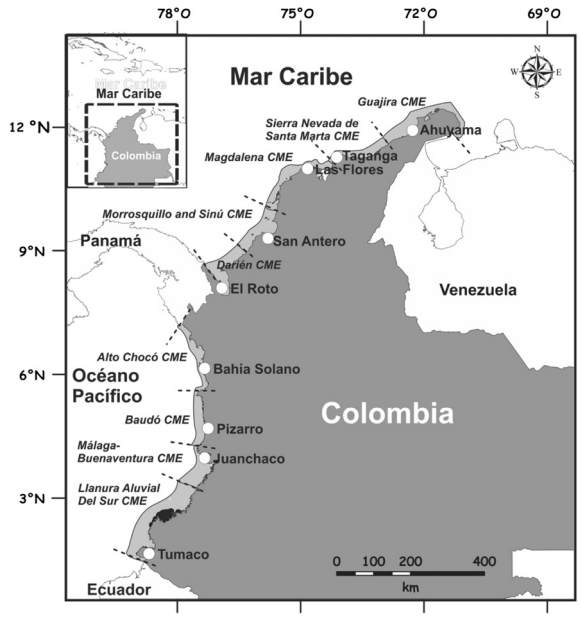

Fig. 1 Map of the selected fishing community (*white dots*) in coastal and marine ecoregions (CME) on the Colombian Caribbean coast and Pacific coast (Taken and modified from Posada and Rozo 2005)

(San Andrés and Providence Archipelago, San Bernardo, Malpelo and Gorgona Islands) are not included this study they should be included in future efforts to improve Colombian fisheries management overall.

The following parameters were employed in identifying one "typical" community in each CME: (1) it was not located in a marine protected area or on an island; (2) it was historically recognized as a fishing community; (3) it relied on fishing as a primary economic or subsistence activity; (4) there existed some level of fisher's organization (formal); (5) the community was involved previously in research projects; (6) there was a low incidence of violence or drug trafficking (for safety); and (7) it had been considered by Fishery experts.

Caribbean coast fishing communities selected in each coastal and marine ecoregion (CME) for this study (Fig. 1) include *Ahuyama* in the Guajira CME, *Taganga* in the Sierra Nevada de Santa Marta CME, *Las Flores* in the Magdalena CME, *San Antero* in the Morrosquillo and Sinú CME and *El Roto* in the Darién CME. Pacific coast fishing communities selected in each CME are *Bahía Solano* in the Alto Chocó CME, *Pizarro* in the Baudó CME, *Juanchaco* in the Málaga-Buenaventura CME, and *Tumaco* in the Llanura Aluvial del Sur CME.

Data sources

The fishermen, local leaders and fisheries experts were interviewed concerning their solutions to the identified problems that are affecting the small-scale fisheries communities and the marine fisheries resources they depend upon for food and livelihood. In addition, fishermen at community meetings were asked questions about their interest in, readiness for and how to move toward fisheries co-management. Fishermen are defined here as coastal marine small-scale fishermen or fisherwomen, including a great

variety of racial and ethnic groups and are directly involved in fishing activities. Local leaders include presidents of local fishing associations or persons recognized as influential members of the fishing community including traditional authorities who fishers look to for leadership and who bring a broader perspective than just of a single fishermen. Finally, fisheries experts are scientists and technicians from Colombian fisheries institutions and administration with expertise and experience working with fishing communities, fishermen and marine resources. Semi-structured interviews of 309 people were conducted. Table 1 shows the number of interviews undertaken for the Caribbean and Pacific coasts per stakeholder group per community.

Fieldwork performed in the fishing communities took place from August 2008 to August 2009 and lasted approximately one month within each community. To collect the fishermen and local leaders' perceptions about fisheries management solutions, a representative sample of leaders and fishermen in each small- scale fishing community were chosen (Table 1). The great variety of the fishing communities imposed important methodological limitations. For instance, fishing communities vary in population from villages such as *El Roto* with 50 Fishermen, to municipalities such as *Tumaco* with 4000 fishermen. In high population fishing communities such as *San Antero* on the Caribbean and *Tumaco* on the Pacific community leaders identified neighborhoods populated mainly by fishermen, for whom fishing activity and proximity to landing places determine where they live. Some municipal fishing communities also cover a much larger area than others (*Tumaco* extends over 167 counties). Therefore, the number of *Tumaco* fishermen involved in the study was low compared to the total number of fishermen in the community, and most came from the municipal center so that peripheral areas were under-represented.

Small communities with fishing populations of around 200 were simpler to sample. The lead author lived approximately three weeks to one month in each community and developed a greater understanding of the situation those fishermen faced. Recognizing these limitations is important in understanding the results of this research.

Community leaders were interviewed first upon arrival at each community. Local leaders identified the principal fishing gears used locally and explained the general

Table 1 Number of semi-structured interviews and number of fishermen performed in each stakeholder group on each community and eco-region on each coastal region

Methods	Caribbean					Pacific				Total number of participants by method
	Ahuyama	*Taganga*	*Las Flores*	*San Antero*	*El Roto*	*Bahía Solano*	*Pizarro*	*Juanchaco*	*Tumaco*	
Fishermen interviews	18	23	31	36	17	14	15	18	23	195
Leaders' interviews	2	3	4	6	1	4	2	3	2	27
Fishery experts' interviews	5	8	5	6	7	2	2	18	4	57[a]
Co-management hearings	17	10 and 18	20	27 and 28	20	35	13	13 and 17	17	235

[a]Thirty interviews performed in 2007 (15 from the Caribbean and 15 from the Pacific) in the feasibility study for the present research have been included in this study, for a total of 87 fishing experts interviews in total

economic, social, and cultural conditions in the community. The interview contained 15 standard questions focused on general subjects pertaining to the local artisanal fishing community. Questions were divided into five main subjects: (1) the role of local leaders in the community; (2) overview of the condition of marine artisanal fisheries; (3) fisheries problems; (4) proposed solutions; and (5) fisheries management.

Given the time and resources available, at least two fishermen from each community were interviewed for every fishing method (i.e., gillnets, mainline, longline, beach seine net with bag, harpoon, surrounding net, bottom trawl, among others). While representativeness of such a survey is always challenging, every effort was made to capture a wide range of perspectives. The interview consisted of 89 questions focused on seven main subjects: (1) personal information; (2) demographics and quality of life (family, education, living conditions, among others); (3) current fishing activity (i.e., time spent fishing, reasons for fishing, technology employed, fishing locations, marketing, among others); (4) long term changes in fishing activity and fisheries problems; (5) proposed solutions; (6) fisheries management; and (7) information regarding the community (i.e., relationships with community members, vulnerability to violence or drug traffic, happiness being a fisherman, among others).

In addition to interviews, we also utilized data from public meetings in each community related to the strategy of co- management. The meetings were held where fishermen brainstormed about top-down and bottom- up fisheries management strategies. Exchanging information and opinions, and discussing the co- management process took place in two main steps:

- Fishermen learned about fisheries management strategies, in particular, about co-management. The basic concepts and features of the major types of top-down and bottom-up fisheries management were explained. Examples of traditional management were analyzed and then contrasted with co-management to show the benefits and drawbacks of this process. This basic information allowed them to understand how fishery management has been applied in other countries, what alternatives exist, the benefits communities might gain from co-management, and the importance of working with other fisheries actors (stakeholder groups) in this process.
- An open discussion focused on the following questions:
  What opinions do the fishermen have about management in general and co-management in particular?
  What weakness and strengths within the artisanal fisheries community might affect the success of co- management?
  What first steps could the community take to start the co-management process?

On the Caribbean coast, 141 community members participating in the interviews, while 81 on the Pacific coast were participated (Table 1). In addition, 140 community members participated in the hearings on the Caribbean coast and 95 on the Pacific coast. Even though it was planned to have one meeting per community, in some communities it was necessary to hold two hearings (*Taganga* and *Juanchaco* communities) because of low fishermen participation.

Data analysis

Qualitative information from semi-structured interviews and fieldwork activities was coded into quantitative data then organized and content analysis performed using computer-assisted qualitative data analysis software (CAQDAS), N-Vivo/8 software (García-Horta and Guerra-Romos 2009; Ozkan 2004; Saldaña 2009; Thayer et al. 2007; Yin 2003). Based on Miles and Huberman (1994) and Yin (2003), coding was done by the meaning of phrases, following the elemental method and incorporated in N-vivo. Then, structural coding and the elemental method were used to pre-code questions by creating main categories of common subjects that allow different opinions to be combined in a single category. Sixteen main categories were created corresponding to the common subjects under which the codes are aggregated (Miles and Huberman 1994). Chi-Square tests were used to distinguish between the perceptions of fisheries solutions and the three groups of fisheries stakeholders. Differences in the perceptions of the main categories of fisheries solutions among stakeholders were analyzed using a Kruskal-Wallis test. In addition, Mann-Whitney tests were performed in order to measure differences in perceptions of the same main categories between the Pacific and Caribbean regions. Finally, to explore the relationships between stakeholders' perceptions of fisheries solutions and the marine eco-regions, a redundancy analysis (RDA) was performed. Descriptive statistics (percentages) were used to analyze the results of each stakeholder group and among all stakeholders.

Results

Given the range of actors in Colombian small-scale fisheries, with their varying perceptions, agendas and power, it can be expected that there will be differences in the proposed solutions to the challenges and problems facing the fisheries. Fishermen are focused on the fishing activity, leaders on governing, and experts on technical aspects of management. The theoretical debate over fisheries governance is how to develop a consensus among stakeholders for a governance system that can allow for including multiple stakeholders.

The results are grouped into cross-cutting solutions (identified by the fishermen, local leaders and experts at the same time), inter-group solutions (identified by only two of the three stakeholders), and isolated solutions (identified by only one stakeholder). In addition to the interviews, the results from public meetings in each community related to the strategy of co-management are presented.

Cross-cutting solutions

Fishermen from both coasts identified 133 solutions, of which 25 were represented by more than 3 % of respondents. Leaders identified 121 solutions, of which 38 were represented by more than 3 % of respondents. Experts identified 397 solutions, of which 135 were represented by more than 3 % of respondents. The responses from the three groups generated 22 cross-cutting solutions in eight categories. The Chi Square Test was used to establish the significance of these cross-cutting solutions to the three participant groups (Table 2).

Results show that 11 cross-cutting solutions had a *p-value* less than or equal to 0.05, and thus were ranked at different levels of importance to all three groups, while 10

Table 2 The perception of importance of cross-cutting solutions ranked by the fishermen, local leader and fisheries experts groups and analyzed using the Chi square test

Categories	Cross-cutting solutions	Code	Fisheries experts (%)	Fishermen (%)	Local leaders (%)	X^2	*p*-value
Aquaculture	Explore aquaculture as an option	Aqua	22.50	13.33	37.04	10.66	0.05
Fishermen and communities	Changes in Community attitude	Comm	2.50	5.64	7.40	1.56	0.46
	Changes in Fishermen attitude	Fish	41.25	14.35	3.70	30.28	<0.001
Fishing equipment	Open waters fishing depth sea fish – *pesca de altura*	OpenW	23.75	13.84	14.81	4.09	0.13
Fishing methods	Use friendly gears and recommendations	GearsOk	7.50	9.23	14.81	1.28	0.53
Goverment-Administration	Control over	Control	7.50	4.61	3.70	1.09	0.58
	Find or generate other jobs	Jobs	13.75	14.87	3.70	2.52	0.28
	Government support to real Fishermen	RealFisher	1.25	8.20	3.70	5.16	0.08
	Loan program with clear rules	Loan	11.25	1.02	3.70	15.54	<0.001
Industrial fishing activity	Restrictions on Industrial fishing	IndusRest	12.50	7.69	7.40	1.69	0.42
Organization of Fishermen	Strengthen Fishermen associations	F Asso	25.00	6.66	3.70	20.77	<0.001
	Strength Leaders	Leaders	5.00	0.51	3.70	6.31	0.04
Regulations	Create regulations	Regulate	61.25	50.76	62.96	3.34	0.19
	Create Protected Marine Areas	PMA	10.00	0.51	3.70	15.96	<0.001
	Fishing Zoning plan	Zoning	10.00	10.25	18.51	1.75	0.42
	Regulate gears	Gears	11.25	39.48	14.81	24.80	<0.001
	Increase mesh size	Mesh	7.50	6.66	3.70	0.47	0.79
	Prohibit gill nets	Not-Gill	7.50	19.48	3.70	9.36	0.01
	Change unfriendly methods for environmental friendly	C-Unfriend	11.25	40.00	3.70	31.99	<0.001
	Establish minimum size per spp.	Min-size	10.00	2.05	7.40	8.62	0.01
	Veda-Time closed season	Veda	23.75	17.43	37.03	6.07	0.05

cross-cutting solutions had similar importance. Support for proposed solutions in the category of Government-Administration were not significantly different among the groups with the exception of the need for a loan program for fishermen based on clear rules, which experts felt would be particularly valuable.

All groups perceived with a similar sense of urgency that the government must regulate the fishery sector, that other jobs must be generated to replace fishing and decrease pressure on fragile resources and ecosystems, and that the administration needs to target support for "real fishermen" rather than opportunists (participants used the term "real fishermen" to distinguish between legitimate fishermen like themselves and pretenders who show up when aid is being handed out).

In the category of Regulations, only fishermen placed high importance on the need to regulate the use of gear, to prohibit the use of gillnets, and to exchange damaging gear

for methods that are environmentally friendly. Experts placed great importance on creation of marine protected areas and establishing minimum catch size. For local leaders, the creation of close seasons (*veda*) was particularly important. There was significant agreement in the need to create regulations for fishing. In fact, this solution had the highest representation among the three groups. The category, Organization of Fishermen, was assigned a different level of importance by each group, with only experts emphasizing the need to strengthen fishermen associations.

Non-significant differences in importance were found in solutions in the following categories: (1) Changes in community attitude (Fishermen and Communities); (2) The use of vessels that encourage open waters and deep sea fishing (Fishing Equipment); (3) The need to use environmentally friendly gear (Fishing Methods); (4) Restricting industrial fishing (Industrial Fishing Activity); and (5) The need to establish fisheries zoning in each community, and to increase gill net mesh size (Regulations).

To relate the ranked importance of the perceived solutions with different stakeholders and regions, a redundancy analysis (RDA) was carried out (Fig. 2). In Fig. 2, the first two factors of the RDA explained 63 % of the total variance. The x-axis (F1) represents 44 % of the variation of perceived solutions between fishing communities on the Pacific (positive scores) versus fishing communities on the Caribbean (negative scores). Meanwhile, the y-axis (F2) is showing a gradient of perceived solutions represented 20 % of the variation between the perceived solutions by fishers (negative scores) versus experts (positive scores). Local leaders have low representation, being located almost in the middle of the other two stakeholders.

While solutions proposed by Caribbean communities differed from solutions proposed by communities on the Pacific, differences are not as great as was the case with the problems (refer to Saavedra-Díaz et al. 2015b). The eco-regions of *Alto-Chocó* (*Bahía Solano* fishing community) and *Baudó* (*Pizarro*) are representative of the fishery situation on the Pacific, whereas the eco-region of *Magdalena* (*Las Flores*) is representative of the fishery situation on the Caribbean coast. Conversely, the Pacific eco-regions of

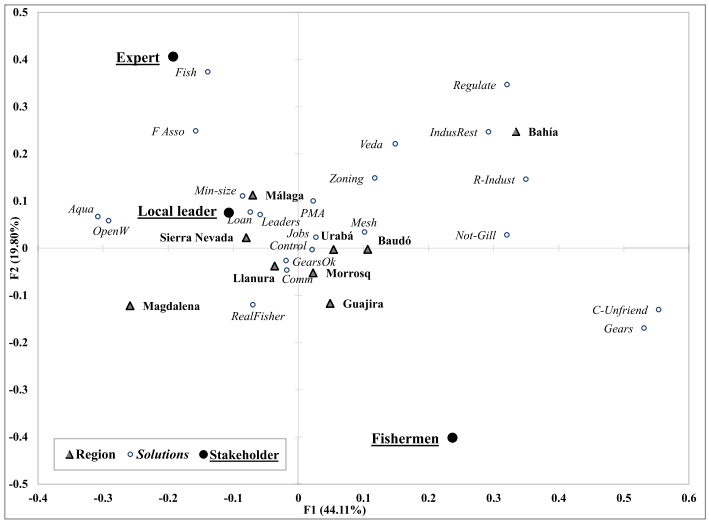

Fig. 2 Redundancy analysis of primary solutions (Cross-cutting) obtained through semi-structured interviews related to ecoregions and stakeholders (explaining variables). The x-axis (F1) represents 44 % and the y-axis (F2) 20 % of the variation

Málaga-Buenaventura (*Juanchaco*) and *Llanura Aluvial del Sur* (*Tumaco*) correspond more closely to the Caribbean situation in terms of perceived solutions. Interestingly the eco-region of *Sierra Nevada de Santa Marta* (*Taganga*) was closer in viewpoint to Pacific communities. On the Pacific coast, the *Bahía Solano* community shared opinions with other communities, but their strong tradition of group deliberation and awareness of the fisheries situation resulted in a clarity of thought that produced more solutions and a wider spectrum of options.

Pacific fishing communities are more aware of the need for regulations (restricting industrial fishing, prohibiting gill nets, establishing closed fishing seasons, fisheries zoning, minimum mesh sizes net, ecologically friendly fishing methods, among others), while Caribbean communities proposed fewer solutions over a narrower range. They focused primarily on the need for oversight and control of fishing activity, change in community attitude, identifying "real fishermen", as well as for strong fishermen's associations, change in fishermen's attitude, exploration of aquaculture and access to open water vessels.

The y-axis (F2) shows how the opinions about solutions of fishers were far different from the opinions of experts. This result supports the impression that the opinions of fishers are not represented by experts. In fact, need for changes in fishermen's attitude (Fish), strengthen fishermen associations (F Asso), and the creation of marine protected areas (MPA) are perceived as important solutions mostly by experts. In contrast, fishers identified solutions that were not considered important by the other two stakeholder groups, such as identifying "real fishermen" (RealFisher), and access to loans (Loan).

All three stakeholder groups identified regulation as the most important solution (fishermen 51 %, experts 61 %, and leaders 63 %). All groups agreed on five additional solutions, but differed significantly on the degree of importance. They are presented in order from the most to the least different. The change from unfriendly (environmentally damaging) to friendly (less damaging) fishing methods ($X^2 = 31.99$; p- value <0.001) was most important to fishermen (40 %). Changes in fishermen's attitude ($X^2 = 30.28$; p- value <0.001) was most important to experts (41 %). Gear regulation ($X^2 = 24.80$; p- value <0.001) was also most important to fishermen (39 %). The fourth and fifth solutions that differ in importance, the need to strengthen fishermen associations ($X^2 = 20.77$; p- value <0.001), and to create marine protected areas ($X^2 = 15.96$; p- value <0.001), were most important to the group of experts.

Inter-group and isolated solutions

There are 37 inter-group solutions which were proposed by the stakeholder groups. These solutions are separated into nine categories (coastal uses and infrastructure, fishermen and communities, fishing resources, government-administration, institutions, marine ecosystems threatened, marketing, organization-fishermen association, regulations). The top solutions in each category are presented in Table 3.

In addition to these inter-group solutions, there were 37 isolated solutions separated in 9 categories (aquaculture, coastal activities and infrastructure, fishermen and communities, government- administration, institutions, national situation, marketing, organization-fishermen association, regulations). The largest number of inter-group solutions were proposed by experts. These included improved fishery information, more research, co-management, and learning about successful management from other

Table 3 Main inter-group solutions shared by two stakeholder groups

Main intergroup solutions	% both coasts		
	Fishermen	Local leaders	Fisheries experts
Coastal Uses and Infrastructure			
Tourism		25.90	2.40
Fishermen and Communities			
Invest in Fishermen Education-read and write		11.11	16.67
Assume responsibility as Fishermen and improve attitude	14.36		7.14
Fishing Resources			
Find new target spp.	0.51		10.71
Goverment-Administration			
Recognition of the importance of Fishermen role and the job-chain involved		18.52	13.10
Empower community	7.20		17.86
Institutions			
Academia important actor		3.70	13.10
Establish Real Fishery institution	3.60		56.95
Marine Ecosystems Threatened			
Recover mangroves and breeding zones		7.40	3.60
Marketing			
Have or improve their own selling and marketing process		14.81	5.95
Improve product manipulation and quality		7.41	5.95
Organization - Fishery Association			
Promote all Fishermen to be associated and the importance of it		3.70	8.33
Support Fishermen in organizing their F.A.		3.70	8.33
Regulations			
National Fishery policy-regulations		22.22	16.67
Work and control fish buyers or merchant		7.41	4.76

countries. Two of these 37 solutions contain sub-solutions. Establishing a real fishery institution was described in 10 sub-solutions, and creating a national fishery policy was identified in 22 sub-solutions.

In order to understand differences at the category level, solutions in the first (cross-cutting solutions), second (inter-group) and third (isolated) orders were combined for analysis. The Kruskal–Wallis test (Kruskal and Wallis 1952) was used here to evaluate differences among categories with respect to the three interviewed groups (Table 4). No significant differences were found in the categories of Fishing Equipment, Fishing Methods, Industrial Fishing Activity, and Regulations; all stakeholders viewed these categories with the same level of importance. Leaders and experts contributed to categories such as Marketing and Fishermen Associations. The former gave great feedback about solutions related to the category of Coastal Uses and Infrastructures. The latter brought substantial investigative experience to the national fishery situation through their knowledge in the categories of Institutions and Government Administration Fishermen were not highly represented in any category compared with the other two stakeholders.

The Mann-Whitney test was used to evaluate differences among the categories with respect to the Caribbean and Pacific coastal regions (Table 5). These results show that

Table 4 Kruskal – Wallis test by the categories of solutions through the three stakeholders groups

Categories	Fisheries experts	Fishermen	Local leaders	X^2	*p*-valor
Acuaqulture	0.225	0.133	0.370		
	(0.420)	(0.341)	(0.492)	10.621	0.005
Coastal Uses and Infrastructure	0.100	0.056	0.370		
	(0.302)	(0.231)	(0.492)	26.86	<0.001
Fishermen and Communities	0.438	0.190	0.444		
	(0.499)	(0.393)	(0.438)	21.35	<0.001
Fishing Equipment	0.263	0.159	0.185		
	(0.443)	(0.367)	(0.396)	3.960	0.138
Fishing Methods	0.075	0.092	0.000		
	(0.265)	(0.290)	(0.000)	2.783	0.24
Fishing Resources	0.125	0.000	0.074		
	(0.333)	(0.000)	(0.267)	24.066	<0.001
Goverment-Administration	0.713	0.333	0.593		
	(0.455)	(0.473)	(0.501)	34.948	<0.001
Industrial Fishing Activity	0.125	0.077	0.000		
	(0.333)	(0.267)	(0.000)	4.388	0.111
Institutions	0.625	0.077	0.037		
	(0.487)	0.267	0.192	105.148	<0.001
Threatened Marine Ecosystems	0.063	0.036	0.148		
	(0.244)	(0.187)	(0.362)	6.132	0.047
Marketing	0.238	0.036	0.148		
	(0.428)	(0.187)	(0.362)	26.471	<0.001
National Situation	0.038	0.000	0.000		
	(0.191)	(0.000)	(0.000)	8.381	0.015
Organization of Fishermen	0.300	0.077	0.333		
	(0.461)	(0.267)	(0.480)	27.77	<0.001
Regulations	0.613	0.508	0.630		
	(0.490)	(0.501)	(0.492)	3.333	0.189
Small Scale Fishing	0.050	0.005	0.074		
	(0.219)	(0.072)	(0.267)	8.409	0.015

Mean relative value (and standard deviation between parenthesis) for each category and stakeholder is shown

category responses on one coast are not significantly different from the other, as was shown in the Redundancy Analysis (RDA).

However, exceptions are seen in categories such as Aquaculture, with higher representation on the Caribbean coast, and Industrial Fishing and Marketing, with greater feedback on the Pacific. This supports the conclusion that solutions on both coasts are basically the same, but that differences in expectations must be part of any management framework.

Fisheries management

The three stakeholder groups – fishermen, local leaders and experts – were asked a number of questions concerning the concept of fisheries management and co-management (bottom-up management).

Table 5 Mann-Whitney test by categories of solutions, comparing Colombia's Caribbean and Pacific coasts

Mann-whitney test				
Categories	Caribbean	Pacific	*U*	*p*-valor
Acuaqulture	0.214	0.122	11743.50	0.043
	(0.411)	(0.328)		
Coastal Uses and Infrastructure	0.112	0.070	11212.0	0.222
	(0.317)	(0.256)		
Fishermen and Communities	0.262	0.304	10297.5	0.427
	(0.441)	(0.462)		
Fishing Equipment	0.166	0.226	10104.0	0.194
	(0.373)	(0.420)		
Fishing Methods	0.086	0.070	10924.5	0.619
	(0.280)	(0.256)		
Fishing Resources	0.032	0.052	10536.5	0.387
	(0.177)	(0.223)		
Goverment-Administration	0.444	0.478	10382.5	0.561
	(0.498)	(0.502)		
Industrial Fishing Activity	0.043	0.148	9623.0	0.001
	(0.203)	(0.356)		
Institutions	0.193	0.261	10017.5	0.164
	(0.395)	(0.441)		
Threatened Marine Ecosystems	0.064	0.035	11068.5	0.270
	(0.246)	(0.184)		
Marketing	0.059	0.165	9608.5	0.003
	(0.236)	(0.373)		
National Situation	0.011	0.009	10774.0	0.868
	(0.103)	(0.093)		
Organization of Fishermen	0.144	0.183	10342.5	0.379
	(0.352)	(0.388)		
Regulations	0.503	0.617	9519.0	0.052
	(0.501)	(0.488)		
Small Scale Fishing	0.037	0.000	11155.0	0.036
	(0.190)	(0.000)		

Mean relative value (and standard deviation between parenthesis) for each category and stakeholder is shown

Fishermen

Only one percent of the fishermen responded that they knew what fisheries management is. These fishermen used a variety of words or phrases to explain the concept, such as organization and order, closed fishing zones, temporary closures, fishermen's association, marketing, control, changing fishing gears, processing fish products, aquaculture, and managing fishing equipment. There is a lack of understanding among fishermen of what fisheries management is.

When asked if their community was ready for bottom-up management, 37 % answered positively and negatively at the same time (42 % Caribbean vs. 28 % Pacific), only 31 % emphatically answered positively (31 % Caribbean vs. 30 % Pacific), 9 % answered negatively (8 % Caribbean vs. 11 % Pacific), and 23 % did not know or were

unsure. Fishermen's answers revealed that they believe fisheries management is necessary because otherwise fishing will get worse (8 %), they need order and rules (7 %), and the community should try and see if it works (4 %). Fishermen reported that some communities have implemented rules by themselves. For example, *Pizarro* established a rule to use gillnets with mesh size larger than 3 in.. *El Roto* established a minimum mesh size of 3 ½ inches for gill nets. The fishermen reported that while most efforts at implementing their own rules have been unsuccessful, they are optimistic that it is possible for fishing communities to come together to establish rules. They felt that it would be possible for the community to implement fisheries management under certain conditions, such as: (1) If all fishermen agree to it; (2) If management is controlled by both community and government; (3) If training in fishery management comes first; and (4) If a subsidy mitigates a fishing restriction. However, fishermen believed that establishing bottom-up management is difficult because: (1) Fishermen's attitude prevents it; (2) It is difficult to get fishers to agree; (3) Some attempts at management had failed in the past; (4) Fishermen cannot stop fishing; (5) It could generate violence among fishers; and (6) Community features complicate the process.

When asked what their community needs to do to manage fisheries, the fishermen believed that: (1) Fishing communities need to get together and agree about implementing management; (2) All fishermen should organize and belong to the fishermen's associations; (3) Fishermen need to face the problems that threaten their livelihood and get specific training to overcome them; (4) Some fishing communities have shown that successful fisheries management is possible, and their experiences can be useful examples; and (5) Fishermen should learn to compromise and explore other job possibilities. When asked what government needs to do to manage fisheries, the fishermen stated that existing regulations needed to be effectively implemented; they should stop foreign fishermen; and training should be provided.

Local leaders

Similar to the fishermen, local leaders knew nothing about fisheries management. When asked if they believed their community was ready for implementing the bottom-up process, 59 % answered positively (63 % Caribbean vs. 55 % Pacific) and 41 % answered negatively (38 % Caribbean vs. 45 % Pacific). A majority of leaders believed they were ready to implement fishery management by themselves because of:

(1) Rules already established by some communities, (2) Strong fishermen's associations, and (3) Community reliance on fishing for food. Leaders believed that bottom-up management is possible, but only if government and community work together. They reported less confidence in efforts developed solely by communities or imposed by the government.

Leaders who were pessimistic about establishing bottom-up fishery management cited fishermen's attitude - according to which the government must give them everything, but they do not make any effort (7 %). Other difficulties include: (1) Low individual representation; (2) Difficulties in getting many fishermen on the same page; (3) Lack of organization or association among the majority; (4) Prevalence of illegal gear that undercuts participation; (5) Lack of understanding of the need for fisheries management; and (6) No institutional authority is in charge.

When asked what they think that the community needs to do in order to manage its fishing resources; local leaders reported that the entire community must get together and agree to actively participate in implementing fisheries management (the process must include fish sellers). They also stated that fishermen must practice responsible fishing, they must develop a sense of belonging, they must belong to a fishery organization, and they must stop using unfriendly gears. When asked what they thought that the government needs to do in order to manage fisheries resources, local leaders reported that government should: (1) Invest in establishing regulations, including making subsidies available while restrictions apply; (2) Establishing exclusive fishing zones for each community; and (3) Closed seasons. At the same time, leaders believe that it is fundamental that any restriction or regulation be discussed with the community before it is implemented and the government should accord the small-scale fishery sector the importance it deserves.

Experts

Fifty-seven percent of the experts believed that it was possible to establish bottom-up management, but 20 % were skeptical. Experts who believed that bottom-up management should work knew about recent, closely related attempts. These included projects in marine protected areas such as *Guapi* and *Sanquianga* Parks on the Pacific coast, led by WWF; San Andres Island on the Caribbean, led by CORALINA; the Special District in *San Antero* that is zoned and planned to preserve mangrove forests; and a similar effort on the Urabá Gulf. Experts described regional or local committees that could be the basis for coastal zoning or for implementing fisheries management, such as NODOS (Regional Institutional Fishery Councils), INVEMAR (regional Committees for Coastal Management), and local Community Councils (some with their own Natural Resources Code). They also listed fishermen's associations that could be local foundations of bottom-up fisheries management, such as associations in *Las Flores* on the Caribbean, and *Juanchaco* and *Bahía Solano* on the Pacific coast. Experts who were skeptical of bottom- up fisheries management doubted that communities would participate. Other concerns were the poor track records of external institutions going in and out of communities makes implementing fisheries management through external agencies difficult; fishermen's attitude and need for constant supervision and their inability to work alone; and cultural aspects of Indigenous fishing communities.

When asked what they think fishing communities need to do in order to manage their fishing resources, the experts believed that a consensus by the majority of the population in each community was necessary in order to obtain high participation. Additionally, the community should discuss and agree upon their own rules and take responsibility for ensuring compliance; fishermen must belong to a fishermen association, and that the community must have a long term vision.

When asked what they thought that the government needs to do in order to manage fisheries resources, the experts felt that the government needs to be aware that bottom-up management requires a long term vision. Additionally, investing in education in order to increase awareness of fishery management; provide active and consistent inter-institutional support in each community; promote and strengthen fishermen's associations; and adapt to community dynamics.

Public meetings

A series of public meetings to discuss fisheries management were held in selected communities – five communities on the Caribbean coast and four on the Pacific coast. The meetings introduced fishermen to the basics of fishery management, why it is important, how they can be part of this process and start to work from their own communities. After presentations, open discussions allowed the participants to express their individual opinions about this fisheries management and bottom-up management and whether or not it could be useful and applied in their situation.

Even though all meetings brought up internal weaknesses, most participants believed that bottom-up management was possible if they worked hand in hand with government. The fact that some communities had already established rules resulting from their own deliberations suggested that widespread bottom-up fisheries management may be possible. Most weaknesses identified in the meetings matched those identified in the fishermen survey described above. These include disunity among fishermen, lack of participation, the presence of foreign fishermen, and weak fishermen's associations due to poor leadership. Additional weaknesses include authorities' distrust of fishermen, dislike of authority, distrust among fishermen, lack of education, lack of a sense of belonging, the involvement of fishermen in drug trafficking.

The main strengths each community identified were related to human capital such as strong knowledge and experience in fisheries issues; leaders and traditional authorities who believe that bottom-up management is the only solution; and community experience in establishing their own rules. Some believe that the presence of old, established fishermen associations are key to success. Communities cautioned that government must support local decision making processes and impose agreed-upon rules (*Juanchaco*), otherwise bottom-up management will not work. Communities stated that fisheries management needs to be designed for the long run and applied consistently over time in each community that adopts the process. There was a need to integrate non-traditional fisheries stakeholders, such as fishermen's wives, local schools and universities, and seafood supply chains into fisheries management. This shows the extent to which small- scale fishing is importantly integrated into local and national life.

Although none of the communities expressed that they enjoy optimum conditions for implementing bottom-up management, all realized its importance and expressed an urgent need to start the process. Particular characteristics of each community affected their readiness to put bottom-up fisheries management into practice.

Discussion

The introduction to this paper noted that weak governance has been a major factor contributing to the overexploitation and consequent poor condition of small-scale fisheries and many of the communities that depend upon them around the world. This is no less true and Colombia and the data presented here and in Saavedra-Díaz et al. (2015b) contribute to the global comparison of this important component of the fisheries sector. The latter paper identified a number of different problems facing the Colombia small scale fishery, as perceived by different stakeholders – fishermen, local leaders, and fishing experts. While there were some difference among the stakeholders and between the two regions, several key problems emerged including destructive fishing methods, lack of regulation enforcement, pollution and industrial contamination, lack of public services,

weakness of fishermen's organizations and leadership. The majority of fisheries experts believed that the small scale fishery sector has been largely ignored by government actions. That analysis concluded that these problems require establishing a fisheries management strategy that can prioritize solutions at different levels: national, coastal, and local.

Identification of problems in any given fishery is necessary but ultimately insufficient. A path forward to solving those problems must be developed. Our approach here is to draw on expertise of fisheries, community leaders and in-country experts to highlight that path.

More than 50 % of each stakeholder group believed that implementing a bottom-up fisheries management approach, such as co-management, is possible. While it is clear that what the details of "co-management" means is still not fully shared, it is still notable that there is significant interest in attempting to take action at a local level to address the problems each community faces, and they all face in common. This approach to using co-management is not only seen to have potential by Colombian stakeholders, but also in other Latin American countries that face similar issues due to fisheries crises, such as Mexico (Salas et al. 2015), Costa Rica (Solís et al. 2015), Brazil (Futemma and Seixas 2008), Uruguay (Trimble and Berkes 2015), and Chile (Marin and Berkes 2010). Even in Colombia, there are examples of cases that have tried participatory management with varying degrees of success (Beardon 2008; Delgado et al. 2010; Navia et al. 2010).

It was notable that all of the stakeholder groups recognize two over-riding needs, 1) that governance of the fishery is urgently needed or conditions will continue to decline, and 2) that whether management is top-down or bottom up, no one group can implement effective management. This is the essence of co-management, shared governance, but shared responsibility. Clearly, fishers perceived the need for the government to help them manage some of the biggest challenges including external challenges (e.g., pollution, criminal elements), while government looked to support from fishers in making real change. Local leaders too, needed a greater willingness of fishers to come together and compromise as needed to make changes, and in dealing with the government.

Surprisingly, Colombian fishermen were the most optimistic about co-management among the three stakeholder groups; however, a majority qualified their answers and listed changes necessary for success. These conditions closely relate to changes mentioned by local leaders and government experts answering similar questions about conditions for success. Optimists believed that existing examples of bottom-up fishery management provide evidence that success is possible. However, pessimists highlighted examples of community or external management efforts that failed and made them concerned about the future of bottom-up management.

From different perspectives, concurrence was also reached on the need to train fishermen in fishery management. Fishermen would share local knowledge, communities would participate in management with greater confidence and the government would provide training that gives everyone a vested interest in the process. Basic changes will be necessary in fishing communities, foremost is increasing membership in fishermen's associations. Experts and leaders agreed on the need to promote participatory research in which fishermen-researchers work closely with teams of biologists.

Each group identified changes in government necessary for insuring successful bottom-up management. Both fishermen and local leaders urgently stressed the

need to establish a fisheries agency in order to constantly and consistently oversee the restrictions and regulations agreed to in deliberation. Fishermen and leaders believed that such restrictions would fail without strong subsidies to encourage the compliance of fishermen.

There were some real differences that will need to be resolved in order to make a management system viable. Clearly one of these is the designation of "real" fishermen versus opportunists. In other words, there is a need to develop a shared vision of who is a member of the community and in what capacity, recognized by the community itself, its leaders, and government. Another real difference in perspective, of a different character is the concern fishers have about gear types, particularly gillnets, versus government and leaders support for closed areas. These are not mutually exclusive approaches but a middle ground needs to be developed since it is clearly a major visible issue of concern for many.

Three of the nine study communities were found to have specific features that encourage them to start thinking about fishery management. These are *Ahuyama* and *El Roto* on the Caribbean, and *Bahía Solano* on the Pacific. These are communities with a small fishing population; few fishing methods; small, close- knit fishing neighborhoods; and fishermen's association could easily start the process of fisheries management. These communities were found to have attitudes and activities which support their commitment and awareness of the need for management. It is felt that these three communities could serve as pilot sites for implementing fisheries co-management in the country.

As noted in the introduction, there is a broad theoretical framework for the governance of small-scale fisheries that has been developed by Berkes, Ostrom, Pomeroy and others (Berkes et al. 2001; Ostrom 1990, 2009; Pomeroy et al. 2004, 2011). Colombian small-scale fisheries management does not have all the elements of this framework. However the present paper and previous work in identifying problems and solutions suggests that implementing successful fisheries co-management may now be possible. Long-term direction is needed for fisheries policy in Colombia and it should include a strong governmental framework that enables local bottom-up co-management. Clear a "transition" process, is needed which can be based on these research results, that moves from the current unregulated situation towards sustainable fisheries. Lessons learned as a result of the present study suggest that work during the next five years needs to focus on building strong foundations of social infrastructure during the "transition" stage that will support and maintain viable and resilient fisheries management plans. Particular characteristics of each community affect their readiness to put bottom-up fisheries management into practice. The national framework should be flexible and adaptable to local community needs and priorities. This may be achieved through four activities: (A) small-scale fisheries program of research; (B) social marketing and awareness raising in government and community; (C) restructure governance for co- management; and (D) community organization.

Conclusions

Understanding small-scale fisheries is key to protecting the health of Colombia's coastal ecosystems and improving the quality of life for coastal fishing communities. All stakeholder groups included in this study generally agreed that both old and new problems

could be reduced by implementing co-management strategies at a community level with governmental support. Consistent, long-term policy direction is needed for fisheries in Colombia. If the Colombian administration continues centralized administration of the fishery sector, without adequate support and involvement at the community level, future conditions could well be worse than at present. Socio-ecological systems related to marine and coastal fisheries are fragile, such that fishing communities are vulnerable, food security is at risk, and the health of marine ecosystems is endangered.

All stakeholders engaged in this study believed that bottom-up management is possible in their communities. This concurrence of opinion and the fact that some communities have already established rules resulting from their own deliberations are evidence in favor of co-management. Most communities believed that co-management is possible working hand in hand with government. Communities that successfully established internal rules, which then failed due to the lack of enforcement, prove the need for a partner authority to assist in implementing fisheries management through co-management. This role should fall to national regulatory agencies; however, they often cannot fulfill this role due to frequent changes in policy directions resulting from changes in national administrations.

Effective fisheries management requires a mixture of national and local authority in order to work well, and steps toward a preliminary framework for a two-tiered system are suggested. Hopefully in the future communities will be able to take the lead in local management, and government agencies will grow into trusted partners by coordinating the consistent application of national fisheries policies and protecting national resources against foreign interlopers.

Competing interests
The authors declare that they have no competing interests.

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Maritime Studies

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The loss of fishing territories in coastal areas: the case of seabob-shrimp small-scale fisheries in São Paulo, Brazil

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Abstract

Knowledge of the difficulties, costs, and territorial issues surrounding fishing communities seems crucial to achieve sustainable development goals in marine and coastal zones. However, such knowledge is not always available, sufficient, or even identifiable. The seabob-shrimp small-scale fisheries in the shallow waters of the State of São Paulo, in Southeastern Brazil, plays an important role in coastal livelihoods, providing social and economic benefits for a number of local communities and a premium source of regional seafood. Around 4000 fish-workers produce supplies for restaurants, fishmongers and supermarkets in coastal towns with about 2 million inhabitants. Nevertheless, harbor and naval mooring, the construction of pipelines, sewage disposal, controversial seasonal closures, and marine spatial zoning have all restricted the activity. A territorial approach is here proposed to examine the timeline of vertically implemented laws/regulations that may have resulted in a decrease of territories formerly available to that fisheries, accompanied by a comprehensive outlook of the overall policy context. The shrinkage of fishing territories has been evidenced and the kind of territorial loss detected does not seem to be implicit in cost analysis of fisheries, ecosystem services, or compensation. Top-down policies and a misunderstanding of environmental mitigation programs appear to have been contributing to increasing conflicts, mining multi-stakeholder processes and social justice in contrast to the ascendant economic growth of both the oil and gas and port industries. While economic and political pressures seem to shape current fishing territories, the recognition of the diversity of interests and power asymmetries in coastal zones directs our attention to a vital, often ignored, dimension of social reality. Institutional challenges and recommendations, such as territorial use rights and legal innovations are discussed, adding value to the self-organization of local communities for an effective process of balanced power both within and outside legal marine protected areas.

Keywords: Territorial approach, Coastal stewardship, Environmental policies, Compensation, Marine protected areas, Oil and gas, Dredging, Fishers

Introduction

One of the aspects to be considered in the efforts to enhance stewardship in small-scale fisheries, is the sector's situation in face of the expansion of multiple pressures in coastal zones (Allison et al. 2012; Elliot 2013). Within a multiple-use, common property resource system, not only each extractive and non-extractive use but also the system's ability to

support combined uses should be assessed (Edwards and Stein 1996). Moreover, the context of struggles over access to, and control of resources and space that often emerge from institutional and power inequalities (McCay and Acheson 1987) should not be ignored.

However, there is a clear gap in evaluating the processes and policies that deal specifically with the position of fishing communities in the midst of multiple-use coastal trade-offs, and their related power asymmetries (Huseman et al. 1987; Oekerson 1986). It is unclear whether this is due to the unpopularity of fishing activities among neoliberal environmentally-friendly sectors (Kopnina, 2015), but it seems evident that the reality of small-scale fishers is often invisible to, or disregarded by, both policy makers and the civil society (Gasalla and Tutui 2006; Petersen et al. 2005).

Knowledge on the struggles, costs, and territorial losses of fishing communities seems crucial to fill this gap and achieve sustainable development goals in coastal zones. Furthermore, it is particularly important to the strengthening of environmental stewardship roles and rights at the local level. Nevertheless, this knowledge is not always clear, available, or even identified (Gasalla et al. 2010).

Additionally, it may be difficult to define fishing territories and get them formally recognized by governments, largely due to their volatile physical boundaries, but also because of the increasing competing economic interests for the appropriation of aquatic spaces, land value and real estate in the world's coastal and riverside areas (McNamara et al. 2015). It makes the identification of and claims for formal recognizion of fishing territories challenging. These factors may also explain why the real loss or reduction of fishing territories has been poorly documented and why there is a lack of global and regional estimates of their magnitude.

In this paper, we offer an analysis of the territorial marine loss faced by small-scale seabob shrimp fishers off the coast of São Paulo over recent decades, in order to reveal some of the processes behind the current threats to traditional fishing territories along Brazil's coastline.

The seabob-shrimp small-scale fisheries in São Paulo

The Brazilian State of São Paulo is the country's most populated and urbanized area, with around 43 million inhabitants, and therefore, comprises the largest domestic consumer market (IBGE 2013). The seabob shrimp fishery industry along its coast (Fig. 1) shows major regional socio-economic relevance among local fisheries (Mendonça et al. 2013). It contributes to the livelihoods of a number of low-income coastal communities, providing social and economic benefits as well as a premium source of regional seafood for the general population. Around 4000 fish workers and their families rely on the seabob shrimp fisheries, who supply the product to restaurants, fishmongers and supermarkets in several coastal cities with a combined population of two million (IBGE 2013). The seabob shrimp is a key ingredient in the regional cuisine, providing the base of typical recipes and snacks such as "*peixe ao molho*" (fish in shrimp sauce), "*pastel*" (fried filo-pastry pocket), "*empadinha*" (mini pie), and a low price option among local shrimp varieties.

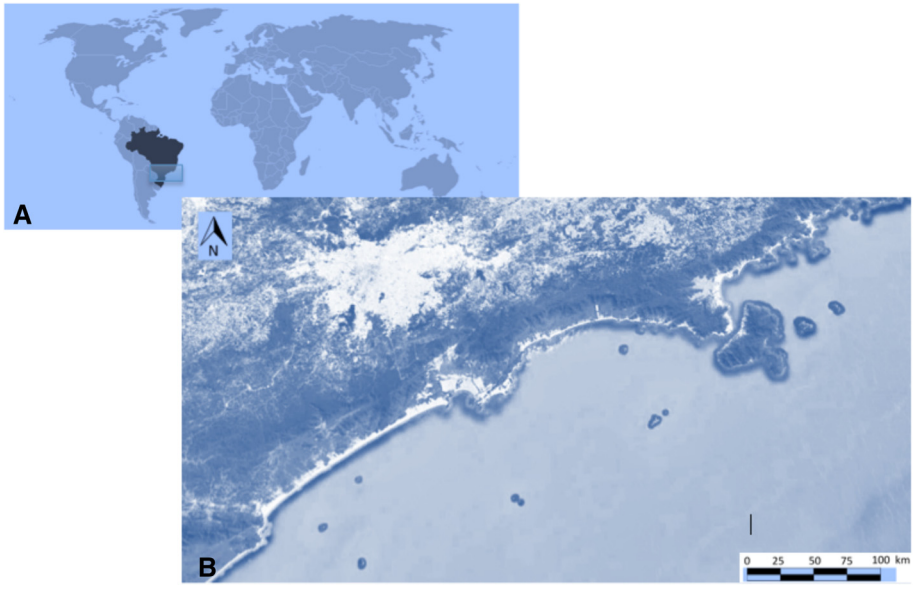

Fig. 1 Map of the study region: **a**- Brazil and the South Brazil shelf area (rectangle); **b**- The coastline of the State of São Paulo, in SE Brazil, Southwest Atlantic Ocean

However, only recently has that fisheries been recognized as the main source of shrimp in São Paulo, following an increase in the coverage of statistics on fisheries' catch data (Mendonça et al. 2013). During the period 2000–2011 it was estimated the seabob shrimp fishery has increased at least ten-fold since 2008. In contrast to what had previously been thought as a predominantly industrial sector, Mendonça et al. (2013) reported that about 75 % of the seabob shrimp fishermen are engaged in small-scale activities responsible for more than 50 % of fishery production in the state. In terms of the fleet, 85 % of the fishing vessels are also classified as small-scale.

The emergence of the seabob-shrimp fishers in São Paulo is quite heterogeneous, ranging from small, traditional, coastal communities ("*caiçaras*") to more recent entries (Lopes et al. 2009). The latter category mainly comprises of families coming from Southern Brazil (that originally worked as shrimp trawlers), and secondarily, of migrants from the Northeast region of the country that settled in mangrove areas similar to their birthplace. Although some parts of the coast in São Paulo are fairly urbanized (e.g., Guaruja) with a certain influx of fishers to traditional areas, those families seem to rely mostly on the sea to get their animal protein (Lopes et al. 2009). The latest settling of seabob shrimp fishers was reported as being due to invitations from relatives, which also indicates that there is no sign of a declining stock, since the returns from the most recent fishing trips suggests a perception of productivity remaining high (Lopes 2008). Families are the basic unit of production and they are totally dependent on shrimp. Shrimp processing plants, that are usually informal businesses, dominate the local economies (Gasalla et al. 2014a; Ykuta and Gasalla, 2014).

The evolution of the seabob shrimp fisheries over the last decade shows an increasing trend in terms of both catch volumes and fishing effort (Fig. 2). This allowed quite a stable annual catch-per-unit-effort (CPUE), which reached average values of 10 kg per fishing-hour between 2005 and 2007. Although statistical data and human perceptions suggest optimism in relation to the stock, the sector faces several threats in terms of

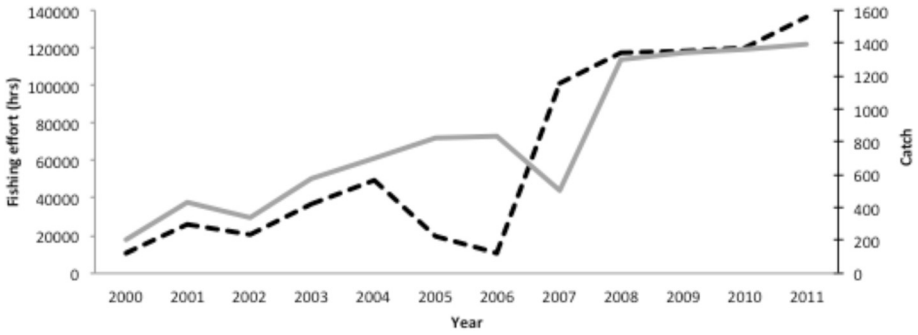

Fig. 2 Fishing effort (dashed line) and catch (in tons, grey line) of the seabob shrimp small-scale fisheries along the coast of São Paulo from 2000–2011 (adapted from Mendonça et al. 2013)

economic viability and performance (Gasalla et al., 2010; 2014b; Souza et al. 2009a). Access rights seem to be decreasing but possible maritime territorial losses have never been estimated before.

Within this context, the present study aimed to evaluate whether the seabob shrimp fishery in São Paulo has suffered any territorial loss and which mechanisms could possibly be underpinning the issue in terms of investment and policy considerations.

A territorial approach to estimating fishing losses

The assessment and management of marine resources is an increasingly spatial affair, meaning that area-based methods are among modern fishery management practices. Impact analyses of energy and industrial offshore developments primarily focus on spatial displacement and access to place-based resources, whilst marine protected areas (MPAs) are widely seen as a key resource management tool (St. Martin 2001; St. Martin & Hall-Arber 2008; Gasalla 2011). On the other hand, notions of fishing territories at the local level, both formal and informal, exclusive and shared, have received considerable attention and reporting all over the world (Kalland 1999). Fishing territories can be short-term, with temporary territorial rights (Forman 1970) or territorial claims (Cordell 1977), or more permanent, such as when a corporation publicly endorses rights to sea space as an estate.

The term 'territory' is used to designate a portion of nature or space that is claimed by a given section of society, aiming to guarantee rights of access to control and use all or part of the resources found there (Godelier 1979; Kalland 1999). A territorial approach may represent a social group whose members act as a legal individual in terms of collective rights to property, and have collective responsibility or other common interests (Keesing 1976). Thus, a territory is more a result of local and regional power than a mere jurisditional definition (Acheson 1979; Gottmann 1973; Raffestin 1993). Sack (1986) adds a flexible and dynamic temporal dimension to the concept, highlighting the notion that human behavior is influenced by the control of access in a particular territory. The term is also applicable to the notions of (1) governance (interaction and regulation between the actors, institutions, and State); (2) social coordination or coordination of the interest groups that takes place in a determined area (Santos 1999); and (3) development (Sabourin 2002).

In Brazil, territory is also seen and understood, from the perspective of rural development and family-based agriculture, as being the new unit of reference and measurement of the State's actions (Schneider and Peyré-Tartaruga 2004). Similarly, considering what could be called a 'maritime rurality' of the *caiçara* communities (Diegues and Moreira 2001), the concept of territory adopted here represents "a space determined by power relationships where the boundaries are sometimes evident (easy to determine) but sometimes not explicit (not manifested), and have the use of space, coexistence, and the co-presence of each person and their activity, as well as the establishment of their relationships as references".

In order to provide a territorial approach to the small-scale seabob shrimp fisheries, an estimate of the fishing area losses was undertaken. Such investigation was limited to an analysis of the formally restricted access to those particular fisheries, although other activities that have not yet been documented scientifically or legally exist in both land and sea areas, suggesting additional conflict of use.

The policy analysis was based on a compilation and examination of laws and regulations that have been affecting the seabob-shrimp small-scale fisheries in São Paulo. The norms that had restricted fishing access were brought together in a GIS database resulting in shape files (SHP) (Fig. 3). The identified areas were uploaded to Google Earth Pro, and their sum was spatially referenced in hectares (ha). This allowed for an area-based estimate to be used as a reference for exploring a territorial approach aimed at identifying "non-apparent" fishing losses. This was followed by the total restriction estimate in relation to formerly available areas, based on the total maritime area stratified per isobaths (30, 20, 15 m depth) and divided by the area of total territorial lost.

The policy analysis was complemented by a comprehensive review of the management system, state of the resource, and interacting norms. This also took into account conflicts and competition between different interests located in history and social systems, including the interactions promoted or sanctioned by central government authorities (McCay and Acheson, 1987),

Policies driving fishing territories loss

Several policies resulted in spatial restricions to the seabob shrimp fisheries in São Paulo, although they were not necessarily implemented to reduce fishing impacts on the ecosystem. In Table 1, the multiple factors affecting fishing territories were classified according to the level of government intervention and policy sector, i.e.

Fig. 3 An example of the maps generated by the territorial approach, derived from shape files (*left*) with all technical information from each different set of data (*right*). Original database is in Portuguese, picture shows original files on trawling restrictions in a particular estuarine region, illustrating the process of area-based estimate

Table 1 Summary of the area-based fishing restrictions data considered in the study, including estimates of total coverage (in hectares) and its relative importance

Regulation type	Level	Number of regulations	Area coverage (he)	Relative importance (%)	Data source	
Federal Fishing Law	Federal	10	6367,2	9,94	São Paulo State Map Data Bank IBAMA/SUDEPE (1967–2004); IBAMA (2010)	Several fishing restrictions norms plus no-take protected areas (MPA) created from the Federal level
Navy Law	Federal	1	1527	0,02	Decree law 9.760/45 (1945); Marinha do Brasil	Military area
Total Federal Regulations	Federal	11	7894,2	12,32		
State Marine Protected Areas	State	5	10517	16,42	São Paulo State Map Data Bank (1987–2013); SMA (2008)	No-take areas in MPAs created from the State level
State Zoning Plan	State	2	37381	58,36	São Paulo State Fishing Map Data Bank (1987–2013); SMA (2008)	Ecological Economic Zone created from Coastal Management Plan
Total State Regulations	State	7	47898	74,78		
Dredged Material Disposal Area	Federal/ State	1	3940	6,15	Polygon defined by federal/state agencies (1995–2012)	See text
São Sebastião Harbour Area	Federal	1	1350	2,11	Decree (2007)	Port enterprise
Santos Harbour Area	Federal	1	1916	2,99	Decree (Portaria-MT 94/95) (1995)	Port enterprise
Sewage Disposal Area	State	6	1052,94	1,64	Sewage location maps (1990–2008); area calculated from 6 infrastructure projects along the coastal zone.	Sewage pipeline disposal
Total infrastructure projects (fishing exclusion areas)		9	8258,94	12,89		
Total	Total	27	64051,1	100,00		

fishing-related regulations, MPAs, coastal zoning, naval activity, and norms due to infrastructure works (enterprise-related no-fishing zones), and the corresponding areas are shown.

In general, Federal-based regulations appeared to be more diverse, ranging from corporations' exclusive zones, marine protected areas (MPAs), and "other fisheries" regulations. The State level regulations fell into two main categories: coastal zoning (ecological-economic zoning established by a formal plan) and marine environmental protection areas (APA) (Table 1). Most of the regulations found are not sea-bob shrimp fisheries-specific, although they do all affect it. In terms of the norms deriving from infrastructure activities, the definition of "dredged material disposal areas" (Santos harbor) has been shared by both Federal and State agencies, which was not the case with fisheries-related regulations.

Overall, the São Paulo State Economic Ecological Zoning Plan was responsible for more than a half (66 %) of all the area-based restrictions that were imposed over a period of almost 50 years (Table 1). Morever, along the São Paulo coastal zone, multiple corporations had legal right to occupy marine areas and to control exclusive zones around their boundaries where fishing is prohibited (13 % of restricted areas).

The MPAs recognized as being restrictive to the seabob-fisheries in São Paulo were found to originate from both Federal and State levels and were defined as 'no-take' areas. The other set of fishing regulations that was found arose from both the Federal level and from zoning plans at State level (Table 1).

On the whole, since 1967, the State of São Paulo has imposed several area-restrictions with 27 norms increasing quantitatively over time in terms of the total restricted area. Restricted area has progressively increased and intensified between 2000–2014 (Fig. 4). Currently these restrictions amount to about 15 % of the entire coastal area of São Paulo state up to the 15 m isobath, 10 % of the 25 m isobaths, and 3 % of the 30 m isobathic area.

Considering the percentage of fishing restrictions in the different depth zones in relation to the whole fishing area previously used by seabob shrimp vessels (from 3 to 30 meters in depth), it appears that the shallower the water, the greater the impact of the policies has been in terms of territorial loss. Therefore, the smaller the scale of the fisheries, the more restrictive the outcome has been.

The fishing area historically operated by the seabob-shrimp fishery is shown in Fig. 5. The dynamics of the maritime territorial transformation in the region can be understood by taking into account the location of "restriction zones" implemented in each decade (Fig. 5). The total loss of fishing territories was estimated to add up to more

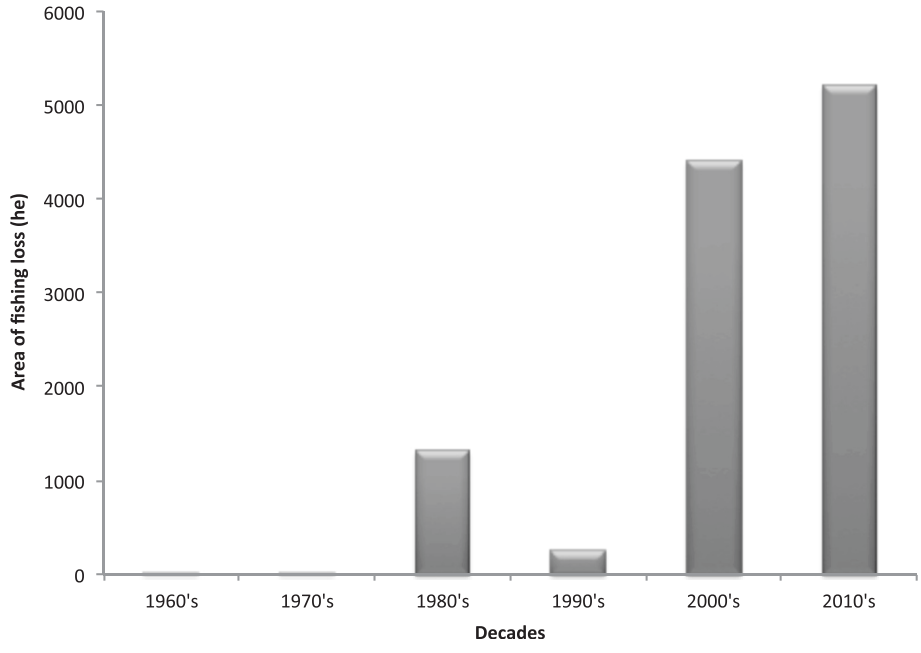

Fig. 4 Total decadal marine territorial loss (in hectares) of the small-scale seabob shrimp fisheries in São Paulo

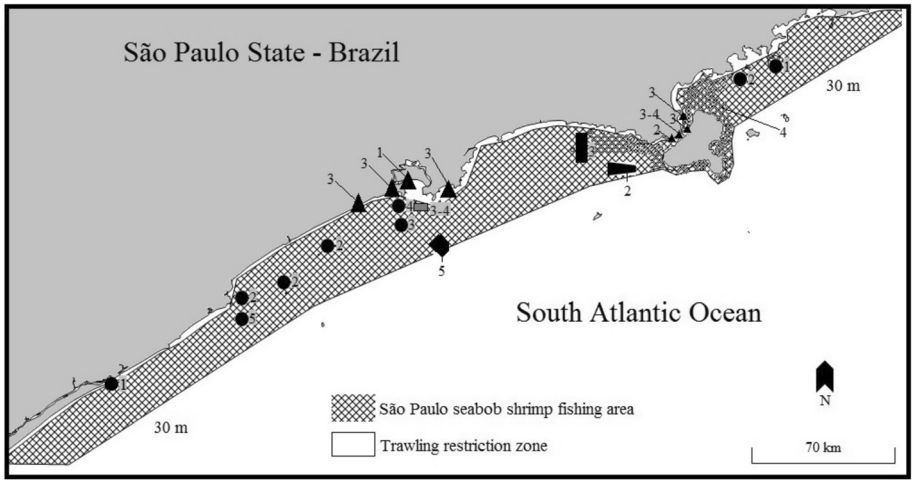

Fig. 5 Location of the historical seabob-shrimp fishing zone off the cost of São Paulo and areas restricted to its fishery across decades (1: 1970s; 2: 1980s; 3: 1990s; 4: 2000s; 5: 2010s). Triangles are infrastructure projects, polygons and the coastal white zones are no-take areas, and the dots indicate (low resolution) closed areas

than 64,000 hectares (Table 1), currently evidencing a correlation between the restriction of fishing areas and the loss of fishing territories as understood by the fishers.

Discussion

The expansion of large-scale industries within fishing territories and the ecological deterioration of the water have triggered heated disputes between enterprises, fishing communities, and the state (Camargo 2014). This study reveals an estimate of the fishing territories formerly available to the seabob-shrimp fisheries that have been reduced as a result of access restrictions due to several distinct reasons beyond conservation. It also reveals a not often recognized state role that imposes restrictions on the small-scale fisheries sector but seems to offer no counterpart of any kind whatsoever for the directly or indirectly decrease in income. The analysis has been limited to the territorial aspect, i.e. the formal area-restrictions imposed on fishing itself. Thus, if environmental health problems that also generate economic losses for fishing communities such as the quality of seawater and seabed (CETESB 2005) are taken into account, the potential impact on fishing territories (or other marine ecosystem service) can be much larger.

Human activities in natural systems that shares common resources (i.e. common pool resources or CPRs) often face two key dilemmas: (a) the 'exclusion problem' (i.e. the exclusion of potential users or the control of access is difficult), and (b) the 'subtractability problem', (i.e. each user is capable of subtracting from the welfare of all the others) (Feeny et al. 1990, Ostrom 1990). In Brazil, the sea and its resources are public assets regulated by the Federal government (Federal Constitution 1988, Art.20). The right to fish is often shared among users divided into different sectors according to licensing criteria defined by national agencies. Access to a fishing area, however, depends on other sea-based activities. The multiple activities that make use of marine areas can be divided into those that depend on the health of the ecosystem and those that are not related to ecological integrity. The former category includes the small-scale fisheries, aquaculture, and sports-related nautical activities as well as non-fishing activities such

as community-based tourism, the small-scale hotel sector, agricultural activities, and restaurants serving sea products. The latter group includes several infrastructure projects that require and occupy the competing maritime space for "industrial logistics" such as ports, oil and gas, traffic, disposal of sewage/run-off, seabed extraction and materials dredged from harbors (Elliot 2013).

Among the several trade-offs in coastal management, we should highlight two important issues: 1) the *limits* of alterations that can be supported in such a way that the development of activities that rely on healthy marine ecosystems may be maintained and allowed; and 2) how far contemporary society can *neglect* a renewable-based economy (which, if well managed, can be sustained for an indefinite period of time) to the detriment of a market-oriented logic that compromises ecosystem services and depends on external factors and motivations far beyond local communities' desires. These dilemmas are clearly observed in the case of the small-scale seabob shrimp fisheries in São Paulo. While both government and civil society make efforts to organize themselves to discuss which institutional arrangement might be best placed to address the tradeoffs abovementioned, the persistence of the invisibility of fishing territorial loss limits the accountability of the economic and environmental policies in generating additional costs for fishing communities, and therefore the development of new policies able to correct this burden.

The reduction of the fishing territories of the seabob shrimp fisheries in São Paulo over the last 50 years were identified as originating from two main factors: 1) the top-down environmental policies, including the creation of MPAs and regulations for other fisheries; and 2) the environmental concession process for the building of enterprise/corporations infrastructures within the coastal zone.

With regards to the former, the process for the foundation of both protected areas and fishing regulations in São Paulo involved very little community participation until 2008, and conflicts with fishing communities were widely reported (Diegues 1973, 1996). Selected participation has taken place since 2002, but only in the State's coastal management zoning plan with the fisheries sector not being well represented. Some defense arguments were however eventually presented by non-governmental organizations (NGOs), but they represented to less that 5 % of the management councils composition. The creation of the 'Marine APA' (a category of State-level MPA) is relatively recent (2008) which does not play a role in the regulation of the seabob-shrimp fishing but has potential for the development of participative mechanisms if well implemented. In some other developing countries, for example in Southern Pacific states, "locally-managed marine areas" have proven to result in a successful effort for spatial management based upon *de facto* communities' participation and agreement (Govan, 2009).

With regard to the territorial losses for fishing due to enterprises and infrastructure, it should be noted that in Brazil an environmental impact assessment is required in order to approve an environmental license (CONAMA Resolution 01/86). However, increasing impact in coastal zones has been heavily criticized in recent decades since the growth of business and infrastructure has occurred faster than that of environmental legislation (Ab´Saber 2001). Although some assessments have attempted to evaluate the impact on fishing areas, in reality, fishing territories have been affected and reduced, and mitigation and compensation mechanisms have been worthless or weakly instituted with insufficient fishers' participation.

This study reveals that the smaller the fishing boat, the more impact it will have felt from public policies (see section 2). This conclusion raises a serious issue concerning equity and social justice. Small-scale fishers have less fishing power as they cannot go beyond exclusion zones, resulting in higher vulnerability to the current regulations that have resulted in about 15 % of territorial loss. Such vulnerability may be seen as a drawback on sustainable development goals (SDGs) and human rights (SDSN 2015). Justice is an important condition for governability, increasing the overall capacity for governance of any societal entity or system (Kooiman 2008; Jentoft 2013). Under injustice, stakeholders are likely to revolt against government efforts to sustain the resource or promoting sustainable development (Jentoft 2013). This also reinforces the view that power and authority are central issues in the analysis.

Fisheries assessment overview: the seabob shrimp stock and its current management

In the study area, there are still controversies over the size of seabob-shrimp populations, as well as over spawning and recruitment seasons. The species is distributed over a wide geographical area and different research groups along Brazil's coastline have reached different conclusions, somehow reflecting the nature of the species which seems to be biogeographically diverse. There is currently a closure season (March-May) in compliance with a legal norm (IBAMA, 2008) that covers the Southern region from Espírito Santo to Rio Grande do Sul States. However, this geographical area is considered excessively large and, according to genetic studies, it comprises more than one different stock/population (Gusmão et al. 2006, 2013; Franscisco 2009, Piergiorge et al. 2014). Moreover, the closure season was originally established rather to protect the pink-shrimp (*Farfantepenaus paulensis, F. brasiliensis*) from the estuaries to the ocean (D'Incao 1991). However, in São Paulo, pink-shrimp is less abundant in the estuaries and seabob shrimp's dominates the coastal zone (Graça-Lopes et al. 1997). Therefore, the time frame currently stipulated by the legislation is also controversial since the current closing period was developed for another shrimp stock with different behavior and population patterns. In fact, Heckler et al. (2013) show the existence of two main periods of female maturation, suggesting that closure for the seabob-shrimp should be brought forward if protection of the spawning season is desired. In terms of the recruitment period, Severino Rodrigues et al. (1992) reported that recruitment of the seabob-shrimp starts as of the species' 20^{th} or 30^{th} month of life and fishery catches contain a considerable amount of young individuals. Notably, adults and juveniles of the stock share areas of equal depth, and the high variability of recruits in the shallow water, resulting from meteo-oceanographic dynamics coupled with the larval survival period, seems to complicate recruitment estimates, while environmental variability might strongly affect stock abundance.

Souza et al. (2009b) report the fishers' frustration towards the continuous changes in the regulations, and highlight the need for further extension work. There seems to be a feeling of betrayal within the sector, since the State creates regulations that are different to those agreed upon at numerous meetings with representatives. Although Azevedo (2013) reminds us that the review of the closure season was fullfilled as part of a participative process, the regulation (IBAMA 2008, IN 189/2008) did not seem to meet

the wishes of either the fishers or the scientific sectors in terms of regionalizing and adjusting the closure to a more appropriate geographical scale. All these factors appear to contribute to an erosion and mistrust of the current fishing regulation process. Apart from the disputes, the management of this fishery seems to have remained static and dated, and is certainly in need of reform.

Despite all the problems, the seabob shrimp stock's CPUE has remained reasonably stable over the last decade, suggesting that overfishing is not in place at least for the target species (Mendonça et al. 2013; Kolling and Avila-da-Silva 2014). A minimum revenue of R$3.00 per kilogram caught by the small-scale fleet was reported as an average in 2008 (Souza et al. 2009a). More recent economic assessments (2012–2014) showed a much higher price variation for the seabob shrimp, suggesting that under extreme conditions of small shrimp catches, the price may vary by up to 500 % during a single year (Gasalla et al. 2014b).

From the perspective of its gastronomic value, the seabob shrimp seems irreplaceable in several of Brazil's most popular dishes. Even in low quantities (such as in 2014), it may acquire a special economic value. Such a substantial price increase would move the seabob shrimp from its traditional category as a "cheap shrimp" to the position of an "irreplaceable shrimp". The gastronomic value and demand is no less important than the biological aspects since its new "status" may increase the small-scale fishers' bargaining power - as an important asset - in the whole coastal management process. Despite the difficulties faced because of the value-chain with a low rate of revenue for the fishers and the lack of collective or public infrastructure (i.e. anchorage piers, refrigeration chambers, subsidized fuel, and small, locally-based shipyards), these fisheries are labor intensive in comparison to other coastal seasonal activities or those that rely on a constant turnover of personnel.

However, participatory approaches may still be considered as being very poor and inefficient. Recently, an oil accident in the Santos Harbor, leading to economic loss for fishers, revealed difficulties in estimating local fisheries yields within the impacted area, constraining fishers to negotiate compensation (Gandini, 2014). The process has been dragged into the courts, which could be avoided should communities have access to, and control of, fisheries information, which seems likely only through participative monitoring (FAO, 1998).

Ways forward

Considering the current fisheries scenario, we argue that community-based participatory monitoring and management could be potentially decisive in preventing the process of reduction of fishing territories that also seem important to seafood supply. In addition to this, we intend to highlight and explore two of the main developments related to the major factors identified by the territorial approach: (i) the territorial use rights for fisheries and a new way of handling fishing communities under coastal MPA regimes; and (ii) the legal innovation for conciliatory dialogue regarding the impacts felt from private enterprises.

Territorial use rights for fisheries and Marine Protected Areas

Notions of exclusive fishing territories at the local level have received much attention worldwide (e.g. Japan, France, New Zealand, and North and South America). The

concept of territory as an area occupied more or less exclusively by an individual or group by means of repulsion through over-defense, or some form of communication, has been tested by ecological models. For example, several authors found correlation between ecological factors and the existence of fishing territories using cost-benefit models developed to analyze territoriality. Dyson-Hudson and Smith (1978), who employ an ecological model to discuss the existence of territories among hunters-gatherers and pastoralists, suggest that territories only exist where the costs involved in defending them are considerably less than the rewards. This fact should help to understand the (non-) territorial nature of fisheries in general.

However, an *a priori* recognition of the existence of fishing territories in certain situations would be a more efficient means of limiting fishing efforts (Kalland, 1999). With smaller territories people are in a better position to influence the resource base on which their future rests, whether the territories are formally recognized and supported by the state or not. Community-controlled territories enhance the efficiency of sanctions, not least because activities at sea cannot be isolated from those on land. Open access seems beneficial only to the more powerful fishers who, with large, efficient vessels, can fish one area after another, and fishing regulations have widely been more of a response to exclusive territories than to the ecological factors theselves (Kalland 1996, 1999).

Mainly because of this, governance over common goods and services has often been transferred from governments to civil society in several fishing area-based cases. For example, Kurien et al. (2006) reported the legal aspects and the social organization process of the aquarian reform (re-territorialization) that has been underway in Cambodia since the beginning of the last decade, as part of which state properties started being regulated locally, resulting in better community access and usufruct rights. In the South Pacific, both the network of "locally-managed marine areas" (LMMAs) in western island states (Govan, 2009), and territorial use rights for fisheries (TURFs) in Chile (Gelcich et al. 2012), have been encouraging fishers to increase their governance powers. Although TURFs cannot be seen as a panacea for solving all fisheries' governance problems, (showing, as they do, constraints beyond the management of benthic resources - Aburto et al. 2014), the concept shows a potential for the context of seabob shrimp fisheries in São Paulo, especially under and within local MPAs.

In 2008, following a quite controversial process, the State of São Paulo created a *continuum* of three APAs where fishing is allowed (Dias and Máximo 2010). However, both the APAs and the coastal fisheries are still threatened by non-fishing impacts such as pollution, oil, sewage disposal, the construction of infrastructure and the effects of large scale tourism. Moreover, progress with respect to the fisheries in these areas has been dismal, even though fishers' knowledge has been well-evidenced as being extremely useful for ecosystem-based fisheries management on the Northern coast (Leite and Gasalla 2013).

Overall, the major weakness in the coastal and fisheries management models found by the present analysis is that they mainly rely upon command-and-control mechanisms, with the adoption of static measures with limited mechanisms for adaptation or updating in the short-term. This has created a great deal of discomfort in the sector. The fishers' distrust in the current bureaucratic management system (e.g. establishment of a closure season different from that agreed upon), the harsh and oppressive manner in which these measures are applied by the State, and the loss of fishing territories that have been found, emphasize the serious need for a series of reforms (Table 2).

Firstly, the current *fora* instituted under the MPAs (APA) management councils could be optimized in a way that promotes a review of the current marine plan under the State's Ecological Economic Zoning (ZEE) as well as the seabob closure season at a more regional level. A new direction to protect the environment and establish territorial use rights for fishers based on genuine and consistent community-based processes at the local level would be recommended. Also, although some MPAs have evidenced real benefits for biodiversity conservation in coral reef ecosystems, it should be mentioned that São Paulo's APAs have a very particular coastal setting and social structure (e.g. a non-reef ecosystems, located in a large portion of the country's coastal zone with stronger social-environmental disputes and economic power which has been gathering public attention due to recent oil and pre-salt discoveries). In this sense, their approach to natural resource management should instead be inspired by other MPA categories within the Brazilian legal framework (SNUC 2000) more appropriated to the socioenvironmental context, such as the Marine Extractive Reserves (RESEX) and Sustainable Development Reserves (RDS) (e.g. see Gasalla 2011).

Lastly, it has been demonstrated that spatially-oriented community-based measures such as TURFs (Panayoutou 1982) or LMMAs could be of particular help in contributing to an increase in the sustainability of fisheries, ecosystem stewardship, and local social wellbeing. If both the food production rights and poverty alleviation needs are recognized in territorial approaches, new ways of governability may advocate for participatory processes (Gasalla 2011; FAO 2014) that should be characterized by transparency, accountability, cohesiveness, and inclusiveness (Jentoft 2013).

Enterprises and legal innovation for public policies

Coastal zone infrastructure projects demand marine space for their activities, using it as logistics channels and an area for deposits, imposing 'subtractability' on fishing areas and excluding other incompatible activities. For example, underwater dredging, sewage and the limitations on the access imposed by port activities and by the oil and gas sector may indirectly create offsets for small-scale fishers. In Guanabara Bay, in Rio de

Table 2 Key observations and suggestions for a participative management of the seabob shrimp small-scale fisheries along the São Paulo coast

Observed facts	Suggested/required action
1. Closures were set in a geographical area that is too large and which do not contemplate the lifecycle characteristics of *Xiphopenaeus kroyerii* neither fishers' knowledge along the São Paulo coastline.	There is a need for more regional and legitimate fishing closures for the target stock.
2. Fishing area entirely within MPAs (marine APA), with conditions to develop self-monitoring and regulation (co-management).	Review and create specific agreements and actions within the marine APAs, since this is an area of legal jurisdiction.
3. Fishermen have participated in the formulation of wide-reaching fishing regulations, but in the case of the seabob shrimp closure they feel betrayed due to not having been consulted or listened to.	Repeal or review of Decree nr. 58.996 (March 25, 2013), and define spatial and temporal regulations based upon collective agreements that need to be reached.
4. Small-scale fishing is responsible for most of the shrimp production along the São Paulo coast, but the current management model, based on police command-and-control, has not shown itself to be applicable or effective whilst it also cannot be understood by the sector.	The implementation of a participative and territorial approach (in the sense proposed by this study) with the recognition of territorial use rights for fishers should enhance coastal stewardship. New policy formulation on environmental licensing should contribute to ethical improvements with this sector.

Janeiro, 75 % of the whole artisanal fishing area has been lost to oil and gas, ports, and infrastructure construction (Chaves 2011). These projects as a whole, often financed by public resources, fall into the accepted practices of environmental licensing that, as a rule, lead to socio-environmental damage, which is hard to equate within the licensing procedure. In the so-called "green economy" paradigm, it should lead to financial compensation and reimbursements in the process of valuing biodiversity as part of business or market values. In Brazil, entrepreneurs are required by law to develop programs for the "socio-environmental compensation" of each of their different projects in order to maintain their environmental licenses. However, these programs are created or designed from the entrepreneurs' perspective with no input from those who suffer the consequent damages. Characterized by a major conflict of interests between those who need the compensation, those who have to pay for it, and those who usually implement the process, a reformulation of such procedures has been recommended (Gasalla 2011). Further analysis suggests that more independent social-environmental programs based on specific territorial use rights, funded and paid for by the enterprise responsible for the loss of fishing territory, and which include non-monetary compensation for the fishing communities, may be an important way forward.

Furthermore, there is a clear opportunity for social innovation (e.g. projects based upon communities' demands) amongst governmental environmental agencies, since it is a public attribution to consider and accept proposals from third parties (e.g. fishing communities). This is something that is already happening, as can be seen in the case of the mangrove areas around Santos Harbour (CETESB 2012).

Another innovation presently under way in Brazil, which is developing in the legal Federal sphere, involves the judiciary's understanding of "mediation" as a method for bringing interests together. A legal development should occur with the approval of the Mediation Law, a new piece of legislation which requires that a negotiation between conflicting parties be part of procedural rites so that environmental injustices are solved extra-judicially based on conciliatory dialogue (Gandini 2014). It is expected that this sort of legal innovation, applied in the social-ecological field, will be a landmark in the field of disputes over spatial use in Brazil and will certainly benefit by a territorial approach to fishing.

In summary, the ways forward embrace the need for a more in-depth territorial approach to fisheries, especially from the perspectives of present coastal zoning, MPAs and the blue-economy. It should include effective participation, the recognition of fishing territories, and innovative processes for environmental licensing, adaptation, mitigation, and compensation. Such participatory approach to fishing (re)territorialization seems to move towards the nationwide mobilizations led by the *'Movimento de Pescadores e Pescadoras'* ('Fishermen's and Fisherwomen's Movement' - MPP) which defends a Brazilian version of territorial use rights as a way to deliver societal benefits and achieve ecological and socio-economic goals in fisheries (MPP, 2012). This also shows a certain amount of agreement with what was proposed by the Citizenship Territories Policy ('*Programa Territórios de Cidadania*') in Brazil in around 2008, which failed to get implemented in the fisheries and aquaculture sector.

Concluding remarks

Fishing activities in the seawaters of the State of São Paulo have been restricted by different policies associated with the installation of specific businesses and aims that go beyond habitat conservation. Despite this, an estimate of the affected (compared to the potential) areas likely to be used by the small-scale fisheries has not previously been conducted.

An examination of non-explicit territories and the related inequalities has assisted this analysis by directing attention to the relevant, but sometimes ignored, social dimension of fisheries in coastal zones. This study has shown that around 15 % of the potential fishing areas of the seabob shrimp has now limited or prohibited entry due to the implementation of a set of coastal zoning policies, and port, oil and gas, and infrastructure projects. These types of zoning goals are considered to be legitimate by the different interest groups, including conservation, but nevertheless mitigation and compensation mechanisms for the small-scale fisheries sector are either weak, undirected, or even non-existent. The kind of territorial loss detected does not seem implicit in a cost-analysis of fisheries and ecosystem services. Fishers' territorial losses amount to more than 64 thousand hectares over time, which took place mostly in the last 15 years.

A more in-depth understanding of the small-scale fisheries sector's real position in multi-goal coastal zone management seems essential in order to enhance its eventual ecosystem stewardship role. The issues revealed here have been discussed within the context of overall policy while a set of recommendations and envisioned directions was presented. A reorientation of investments starting with the country's infrastructure projects leading to innovation in compensation mechanisms and novel environmental mediation methods, an evolution from command-and-control instruments to participative approaches, and the definition of territorial use rights for fisheries were highlighted.

Public interests seem integral to property regimes, and power plays in the distribution of benefits account for institutional change. The facts raised here seem to encourage small-scale fishers to become important players in the coastal zone and fisheries management scenarios. As long as fishing territories are seen, recognized, and granted, a maritime 'rurality', even in more urbanized areas, shows the potential to grant high quality protein in the food production system and to collaborate in both poverty alleviation and the green-economy. It would now be expected that the development of local, territorial approaches and legal innovation in public policies should become a new focus in natural resource and coastal management in Brazil, where "compassionate conservation" (*sensu* Kopnina, 2015) and the recognition of fishing territories can take place.

Our findings might also contribute as "food for thought" in the analysis of the equity and power relationship within coastal policies and conservation goals, the concession of use rights for traditional communities, and on the progressive loss of fishing territories elsewhere.

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