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Marine Protected Areas: Interactions with Fishery Livelihoods and Food Security

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Preparation of this document

This document on Marine Protected Areas: Interactions with Fishery Livelihoods and Food Security has been prepared jointly by the FAO Fisheries and Aquaculture Department and the IUCN Fisheries Expert Group (FEG). It builds on work presented at the IUCN World Parks Congress (WPC) held in Sydney, Australia, on 12–19 November 2014, and contains a total of twelve papers (see list of contributors). The papers have been technically edited by Lena Westlund, Anthony Charles, Serge Garcia and Jessica Sanders.

FAO would like to extend its appreciation to all authors for their contributions both at the WCP and to this document. We are grateful to Linda Mitchell for editing the text, to Enzo Luchetti for the desktop publishing layout and to Gilles Kaboha for the translation from French of the paper on Mauritania. Anthony Charles acknowledges support from the Social Sciences and Humanities Research Council of Canada, through the Community Conservation Research Network (www.CommunityConservation.Net).

Abstract

Building on work presented at the IUCN World Parks Congress (WPC) held in Sydney, Australia, on 12–19 November 2014, this document explores experiences with aquatic protected areas (PAs), marine protected areas (MPAs) and protected areas in inland waters in the context of livelihoods and food security. It includes: (i) ten papers reporting on the interface of MPA/protected areas with livelihoods and food security, based on case studies in Africa, Asia, Latin America and Oceania; (ii) an eleventh contribution providing a more general overview of MPAs and food security and how to assess their impact; and (iii) a final paper synthesizing the conclusions of the papers and discussing the observed outcomes of aquatic PAs, together with problems and solutions.

With a focus on densely populated areas with vulnerable communities, the document's contributions recognize that the assessment of impacts of aquatic PAs on fisheries livelihoods and food security meets with difficulties related to: the newness of the issue in the context of aquatic PAs; compounding effects of external drivers; monitoring costs; lack of empirical evidence and deficient experimental designs; and lack of systematic ex ante and ex post assessments. Nevertheless, it is possible to identify certain key problem areas, associated with the distribution of costs and benefits, the high degree of dependence of fishing communities, the highly dynamic patterns of evolution of the general context of both the fisheries and the aquatic PAs concerned, the difficulty and cost of enforcement, and commonly recurrent financing difficulties. The positive outcomes observed in the case studies presented here relate to improved social cohesion and participation, conservation and incomes, but concerns are also expressed about a lack of attainment of expected outcomes. It is stressed that no generalization on the efficacy of aquatic PAs in supporting livelihoods is possible. Direct measures of impact on food security and poverty are not available. Numerous elements to address the problem are proposed relating to: (i) dedicated policies; (ii) clearer and more comprehensive objectives; (iii) community participation; (iv) communication between stakeholders; (v) building capacity to collaborate effectively; (vi) incorporating a mix of technical and structural measures; (vii) use of traditional knowledge; (viii) systematic recording of empirical evidence; and (ix) compensation, alternative livelihoods and income-generating activities.

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Abbreviations and acronyms

ACA	Agency for Cultural Affairs
ADIO	Ostional Integral Development Association
AIGA	Alternative income-generating activity
ALIGA	Alternative livelihoods and income-generating activity
ARCAE	*Asociación Red Costarricense para el Ambiente y la Educación* (Costa Rican Environmental and Educational Network)
CBC	Community-based conservation
CI	Conservation International
CONAMAR	*Comisión Nacional del Mar* (Council for the Seas)
CTI-CFF	Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security
DMP	Development and management plan
EAF	Ecosystem approach to fisheries
EEZ	Exclusive economic zone
FAO	Food and Agriculture Organization of the United Nations
FCA	Fisheries cooperative association
FIBA	Fondation Internationale du Banc d'Arguin
FMO	Fishery management organization
GBR	Great Barrier Reef
GRET	Groupe de Recherches et d'Echanges Technologiques
HFCA	Hinase Fisheries Cooperative Association
ICRI	International Coral Reef Initiative
IDR	Indonesian rupiah
IMROP	Institut Mauritanien de Recherches Océanographiques et des Pêches (Mauritanian Institute for Oceanography and Fisheries Research)
INCOPESCA	*Instituto Costarricense de Pesca y Acuicultura* (Costa Rican Fisheries and Aquaculture Institute)
KJNP	Karimunjawa National Park
LMMA	Locally managed marine area
MINAE	Ministerio de Ambiente y Energía (Ministry of Environment and Energy)
MMAF	Ministry of Marine Affairs and Fisheries
MPA	Marine protected area
MRO	Mauritanian ouguiya
MSC	Marine Stewardship Council
NPOA-SSF	National Plan of Action on Small-Scale Fisheries
NTA	No-take area
NTZ	No-take zone

ONWR	Ostional National Wildlife Refuge
PA	Protected area
PEM	Participatory environmental management
PNBA	*Parc National du Banc d'Arguin* (Banc d'Arguin National Park)
PRETOMA	*Programa Restauración de Tortugas Marinas* (Sea Turtle Restoration Program)
RMFA	Responsible marine fishing area
SIMP	Solitary Islands Marine Park
SINAC	*Sistema Nacional de Áreas de Conservación* (National System of Conservation Areas)
SRFC	Subregional Fisheries Commission
SSF	Small-scale fisheries
TBIE	Theory-based impact evaluation
TNC	The Nature Conservancy
ToC	Theory of change
TSMP	Tun Sakaran Marine Park
TURFs	Territorial user rights in fisheries
UCR	University of Costa Rica
VPDI	*Vers une Pêche Durable Imraguen* (Towards Sustainable Imraguen Fisheries)
WCS	Wildlife Conservation Society
WNP	Wakatobi National Park
WPC	World Parks Congress

Introduction

BACKGROUND AND CONTEXT

This document builds on work presented at the IUCN World Parks Congress (WPC) held in Sydney, Australia, on 12–19 November 2014. It explores experiences of aquatic protected areas (PAs), marine protected areas (MPAs) and protected areas in inland waters in the context of fisheries, livelihoods and food security.

Aquatic resources form the basis of food security and livelihoods for many millions of people around the world and responsible resource management is a prerequisite for sustaining their livelihoods, well-being and food security, now and in the future. Overexploitation of resources, environmental degradation, social inequities, tenure insecurity and poverty are some of the interconnected threats in the lives of many coastal and rural communities.

The use of aquatic PAs as a tool to protect aquatic ecosystems and reverse the degradation of habitats continues to receive increasing attention. Aquatic PAs, in particular marine protected areas (MPAs), are also increasingly being promoted as a measure for addressing overfishing and unsustainable resource utilization. Spatial-temporal fishing closures, including full closures, as a management tool have a long history in fisheries and predate the current concept of aquatic PAs for biodiversity conservation. However, for fisheries management and the promotion of sustainable use of resources, while PAs may have a particular role in protecting habitats and some non-target species, they are only one tool among many, and are not necessarily the most effective one. Moreover, while aquatic PAs are often nested in the environment and livelihoods of fishing communities, their contribution to and impact on these livelihoods and food security tend not to be well known.

An opportunity to explore these issues arose at the 2014 World Parks Congress (WPC). The IUCN organizes WPCs every ten years; these events are major gatherings for those interested in land- and/or water-based protected areas, providing an opportunity to exchange experiences and share knowledge from across the globe. While the WPCs are not decision-making fora as such, they are still important for shaping future thinking with regard to PAs. At the 2014 WPC, the Food and Agriculture Organization of the United Nations (FAO) and Fisheries Expert Group of the IUCN Commission on Ecosystem Management (IUCN/CEM/FEG) co-organized events focusing on marine and freshwater PAs and their, fisheries, local livelihoods and food security. Two sessions and a side event were organized:

- A Session on *Marine protected areas (MPAs) and sustainable livelihoods* discussed interactions of MPAs with sustainable livelihoods in the context of their multiple attributes as potential tools for fisheries management and biodiversity conservation, including their potential social and cultural dimensions. Case studies were presented, intended to illustrate how MPAs can positively or negatively affect livelihoods and livelihood options, through both fisheries and non-fisheries activities including disaster risk reduction.
- A Session on *Marine protected areas (MPAs) as a tool for food security* examined the contribution of MPAs to food security through its use in relation to fisheries management. The session was based on the premises that addressing unsustainable resource utilization requires better understanding of the role that the range of fisheries management tools can play, including MPAs. In this context, the session discussed how MPAs can have positive outcomes for both conservation and food

security, how to ensure stakeholder participation and what trade-offs between conservation and resource utilization specifically need to be dealt with to ensure food security and sustainable livelihoods.

- A side event on *Connecting the dots: Marine protected areas (MPAs) and sustainable small-scale fisheries* focused on MPAs and small-scale fisheries, and more specifically on how the recently approved *Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines)* can be implemented in the context of MPAs. The links with other international instruments, guidance, studies and experiences were explored and views and ideas from participants on how to strengthen MPA governance with respect to small-scale fisheries were collected.

CONTENTS AND STRUCTURE OF THIS DOCUMENT

This document includes papers building on ten presentations made at the sessions described above, focusing on the interface of MPA/PAs and livelihoods-food security in coastal and inland water areas based on case studies in Africa, Asia, Latin America and Oceania. Their content could be summarized as follows.

Laely Nurhidayah and Shawkat Alam examine the relationship between MPAs and fisheries in the context of food security and sustainable livelihood in Karimunjawa National Park and Mayalibit Papua protected area of Indonesia. Based on the notion that there can be conflicting interests between local fishing communities and government conservation objectives, they examine how competing objectives of conservation and food security can converge through trade-offs to promote sustainable livelihoods and, based on that experience, discuss adaptive planning and management strategies.

Andrew B. Bystrom analyses small-scale fishery development within Costa Rica's MPA system. He uses the Bejuco fishery – an artisanal bottom longline snapper fishery – as a case study to analyze the ability of Costa Rica's MPA system to provide small-scale fisheries with the necessary framework to facilitate their socio-ecological development. The Bejuco fishing community was not consulted during the political MPA design process, which led to a number of management concerns and problems. Fishers are now working with researchers and other stakeholders to identify sustainable resource extraction (fishing) methods, apply for a Marine Stewardship Council (MSC) certification, and restructure the existing chain of custody.

Jan van der Ploeg and his colleagues look at freshwater PAs to protect biodiversity and improve food security in the Philippines. Freshwater ecosystems in the Philippines are severely degraded by overexploitation, pollution, invasive species and rapid land-use changes, threatening food security and biodiversity. The authors describe the efforts made to establish a network of community-conserved areas with the dual aim to improve inland fisheries and protect the Philippine crocodile in the wild. They note that implicit cultural values, such as hospitality and respect, are often a more important motivation for rural communities to conserve fish, wetlands and wildlife than explicit concerns about food security and livelihoods.

Izumi Tsurita and colleagues examine the relationship between fishers and conservation, sharing the case study of the Hinase area in Bizen city, Okayama Prefecture in Japan. The regulations and practices of Japanese MPAs conform to various existing systems with most of them having fishery resource management objectives. The outcomes of two years of research are described with a specific focus on conservation, food security, sustainable livelihoods and fisheries. Linkages and trade-offs between conservation and resource utilization are described, as well as specific lessons learned for successful MPA management by the local fishers sharing particular social systems.

Warrick J. Fletcher reflects on the changes in fisheries production that followed a large-scale expansion of no-take closures within the Great Barrier Reef, Australia, illustrating the results of the closure, the debate on these outcomes and the implications of lessons learned for policies related to food security. In July 2004, an additional almost 30 percent of the total Great Barrier Reef region off Queensland, Australia, was closed to all fishing. The expectations were that these additional closures would generate minimal (10 percent) initial catch reductions and that recovery would become apparent after three years. However, a study that examined the commercial catch data over this period found an immediate decline of over 30 percent with no recovery nine years after the closures. The author presents some of the arguments in the controversy that followed the presentation of these results, and explores the potential costs and benefits of area closures for the delivery of food security outcomes.

Djibril Ly proposes alternative solutions to support the ongoing change of the traditional Imraguen society in the Banc d'Arguin National Park (PNBA) in Mauritania, through support for adding value to their fishery products. Created in 1976 by the Mauritanian Government to protect the most important areas of reproduction and concentration colonies of waterbirds in West Africa, the PNBA is the second largest MPA of the African continent with an area of 12 000 km². The author highlights the experiences of the PNBA in supporting its local communities, especially the Imraguen women for whom the park development led to a decline in their fish processing activity. The author also presents solutions for comparable MPAs aiming at strengthening fishing communities' resilience.

Carlos Mario Orrego and Norma Rodríguez describe the positive relationship between the local community and the conservation of olive ridley sea turtles at Ostional National Wildlife Refuge (ONWR) in Costa Rica. The national government established a wildlife refuge in Ostional in 1983 and authorized the Ostional Integral Development Association (ADIO) to use olive ridley sea turtle eggs as a way of subsistence (consumption and selling) in 1987. The authors show that for an MPA to be effective at both protection of nesting turtle populations and provision of socio-economic benefits to improve livelihoods to the local human populations, the key for success lies in the local ownership of the management plan and strict law enforcement.

Ambroise Brenier and Aurélie Vogel look at the integration of conservation and development in Madagascar's MPAs. In the past decade, the number of MPAs in Madagascar has increased dramatically. Most of the new MPAs emphasize a balance between conservation and sustainable use of natural resources, and focus on empowering local communities to take greater responsibility for marine resource management. It is usually agreed that the practice of regulating fisheries by conferring management rights and powers to local communities holds great potential for sustaining dispersed small-scale fisheries and improving people's livelihoods. The authors describe how two organizations – the Wildlife Conservation Society (WCS), an international conservation non-governmental organization (NGO), and Groupe de Recherches et d'Echanges Technologiques (GRET), a French development NGO – have worked to produce positive impacts on both conservation and local communities' food security and livelihoods.

Nicola Johnstone and colleagues show that oral histories highlight the varied impacts on commercial fishers' livelihoods produced by the introduction of the Solitary Islands Marine Park (SIMP), in northern New South Wales, Australia. Their paper documents oral history interviews with seven commercial fishers in the SIMP to investigate the connections and values associated with it. They argue that oral histories, through memory and reflections of long-term knowledge holders, can: (i) provide insights into positive and negative impacts of MPAs on commercial fishers' livelihoods; (ii) have the potential to influence future management; and (iii) in marine resource

planning and management, contribute to global aspirations of a more productive ocean and sustainable industry.

Nastasha Stacey and her colleagues look at the impacts of MPAs on livelihoods and food security of the Bajau, an indigenous migratory people in maritime Southeast Asia. They note that area-focused conservation strategies such as MPAs often conflict with the reality of local cultural and livelihood practices of migratory or semi-nomadic maritime indigenous groups. These groups are highly mobile in their dependence on marine resources and are vital actors in efforts to develop sustainable management strategies over seascapes. The authors seek to identify: (ii) tensions between mobile resource users and different place-based conservation and marine resource management systems; and (ii) policy recommendations for managers and user groups that build on previous resolutions and declarations. In so doing, the authors examine aspects of mobility as a livelihood strategy and cultural identity among specific indigenous groups, and draw from MPA-related case studies in Southeast Asia, eastern Sabah, Malaysia and eastern Indonesia.

The above ten contributions are followed by an eleventh contribution, by Christophe Béné, that provides a more general overview of MPAs in relation to food security and how to assess the impact of the former on the latter. In particular, Béné focuses on the effects of marine reserves (no-take), based on the premise that the well-being of their neighbouring human populations is one of the most controversial debates in conservation policy, in particular in developing nations. Béné explores the reasons underlying a lack of robust evidence about the relation between marine reserves and food security, arguing that a part of the problem has been the inability to generate enough rigorous and robust evidence about the exact nature of the relation between conservation and human development. Using a discourse analysis, he shows that the failure to provide evidence is not necessarily due to a lack of appreciation for basic monitoring and evaluation principles, but results instead from the rhetorical basis on which the decision to establish marine reserves is usually built, leading to a lack of baseline data collection. Béné then builds a generic Theory of Change of the effects of marine reserves on the food security of local populations and uses it to show why most of the more recent and more rigorous impact evaluations published in the last few years are still unable to determine how and why a marine reserve does (or does not) contribute to food security. He suggests addressing this by instead using an approach based on theory-based impact evaluation.

The last paper of this volume synthesizes the conclusions of the papers and discusses the observed outcomes of aquatic PAs, together with problems and solutions.

A NOTE ON TERMINOLOGY

A challenge when discussing PAs is the terminology as there tends to be a large variation in the names used for MPAs and other aquatic PAs around the world. The definitions of PAs also vary and there are different types of PAs with different levels of protection. IUCN uses six categories ranging from strict nature reserves to areas managed for the sustainable use of natural ecosystems. Sometimes PAs are multipurpose, including both no-take areas or zones (NTAs or NTZs) and zones where certain types of fishing are allowed. In this volume, the authors of the different papers use the terminology appropriate in their specific contexts and there is, hence, some diversity. Readers are recommended to keep this in mind and consider the descriptions and explanations given.

Marine protected area and fisheries in the context of food security and sustainable livelihood in Indonesia: a case study of MPAs in Karimunjawa and Mayalibit Papua, Indonesia

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BACKGROUND

The Indonesian archipelago has one of the world's highest concentrations of marine biodiversity. Loss of marine biodiversity is greatest in coastal areas, largely as a result of the conflicting use of these habitats, land-based marine pollution, destructive fishing practices and overfishing. Marine protected areas (MPAs) are only a part of the conservation strategy needed to conserve marine biodiversity and replenish fish stock. For fishers, MPAs are associated with no-take zones (NTZ) where fishers are prohibited from fishing in certain areas (core zone) which usually have an abundance of fish. An MPA is supposed to have a positive effect on biomass and fish stock, with a spillover of fish improving the yield of nearby fisheries. However, some local fishers do not perceive any benefits, rather the fishing restrictions threaten their livelihoods and negatively affect their food security. Previously they could freely catch fish or turtles. Therefore, conservation of marine biodiversity through MPAs should be balanced and integrated with the priority to support community well-being (Pomeroy, Mascia and Pollnac, 2006:149; Rodriguez *et al*., 2007, in Parsons *et al*., 2014; Parsons *et al*., 2014).

However, this proves difficult where government and fishery communities have conflicting interests, namely conservation versus livelihood improvement and food security. Support to establish MPAs has grown among different tiers of government and local communities. Yet, while the local communities support their own grassroots management regime significantly, they have lingering resistance over the establishment and management of MPAs, particularly by the government. Indonesia has 566 conservation areas (36.07 million ha), with 490 terrestrial areas, and 76 marine and coastal conservation areas (13.5 million ha) (Yunia, 2010). The national and local governments manage most of the MPAs, with local communities managing small areas.

Legislation in the form of Conservation of Living Resources and Their Ecosystem (Law No. 5 of 1990) mandated the Ministry of Forestry,[1] currently the Ministry of Environment and Forestry, to establish marine conservation areas and national parks. Furthermore, the enactment of Fisheries Law No. 45 of 2009, amending Law No. 31 of 2004, and the Management of Coastal Areas and Small Islands Act No. 27 of 2007 allowed the Ministry of Marine Affairs and Fisheries (MMAF) to establish national and local marine conservation areas to be managed by national and local governments. Law No 1/2014 on Changes to the Law No. 27/2007 on the Management of Coastal Areas and Small Islands, article 78A states that conservation areas in coastal and small island areas designated before the enactment of this law are subsumed under the authority of the MMAF. Therefore, the Ministry of Environment and Forestry should have transferred the management of national marine conservation areas to the MMAF. However, in practice the Ministry of Environment and Forestry still manages seven marine national parks.

This paper examines MPA-fishers interactions, and the effects of MPAs on livelihoods and food security, be they positive or negative. One case study was conducted in Karimunjawa National Park (KJNP) and another in Mayalibit Bay, both in Indonesia, and data was collected during interviews and focus group discussions. KJNP, established in 1999, is a marine and terrestrial national park covering a total area of 111 624 ha: the marine area is 110 117 ha and was declared an MPA in 2001, and the terrestrial area is 1 507 ha. The terrestrial area includes the tropical forest on Karimunjawa Island and the mangrove forest on Kemujan Island. The KJNP case study participants were fishers from four villages, the KJNP/MPA authority (national government) and the Wildlife Conservation Society (WCS), an NGO. The Mayalibit Bay case study involved fishers from 7 of the 11 villages on the bay, the MPA authority (local government) and Conservation International (CI), an NGO.

This paper concludes that the success of MPAs depends on multi-stakeholder involvement during the planning, implementation, and monitoring and enforcement stages of an MPA. Accountability, transparency and inclusiveness are the foundations of good governance and management, such as community support of legal frameworks in sustainable fishing initiatives. Governments should empower local fishers to improve their livelihood and should provide an alternative to fishing for a livelihood.

MPA-FISHERS' INTERACTION IN KARIMUNJAWA NATIONAL PARK

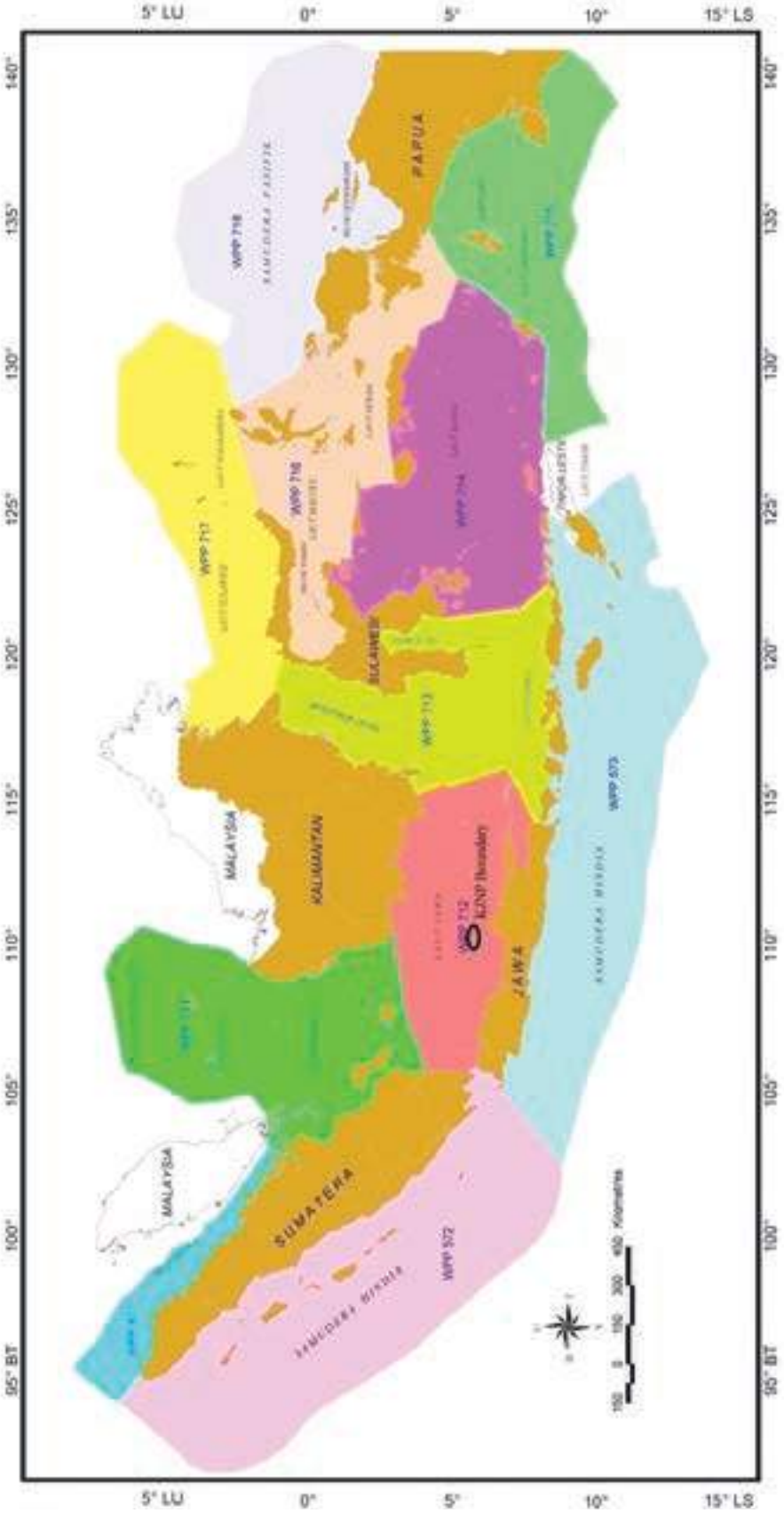
MPA governance

A map of Indonesian fisheries management areas is shown in Figure 1. On the map, KJNP with its MPA appears in management area WPP712. The MPA when established in 2001 (Ministry of Forestry Decision No. 74/Kpts-II) was governed by the Ministry of Forestry and from 2014 by the Ministry of Environment and Forestry. It is located in the Java Sea, 16 miles north of Jepara, Central Java, and administered by Jepara regency, the local government. KJNP MPA covers 110 117 ha and contains 22 islands[2].

[1] The Ministry of Forestry merged with the Ministry of Environment during the Jokowi Administration in 2014 and became the Ministry of Environment and Forestry.

[2] Campbell, S.J., *et al*. 2012. Map of Karimunjawa National Park, Indonesia. (Available at Figure_1.tif. PLS ONE.10.1371/journal.pone.0050074.g001)

FIGURE 1
Map of the Indonesia fisheries management areas



Source: MMAF Decree No. 01/MEN/2009.

In KJNP, the four villages studied are Karimunjawa village on Karimunjawa Island, Kemujan village on Kemujan Island, Parang village on Parang Island and Nyamuk village on Nyamuk Island. Parang and Nyamuk villages are reached by boat from Karimunjawa village in about two hours. The 22 islands inside KJNP and the 5 islands outside KJNP are collectively referred to as the Karimunjawa Islands.

FIGURE 2 AND 3
Cooler boxes at a landing site in Nyamuk village and fishers arriving home from fishing in the afternoon in Karimunjawa village

Source: Photos courtesy of Laely Nurhidayah.

To manage the KJNP MPA and terrestrial areas effectively, seven zones were created (Decision of the Directorate General PHKA, Ministry of Forestry No. SK 79/IV/Set-3/2005). These zones include:

- the core zone (444.692 ha) where fishing is prohibited;
- the protected zone (2 587.711 ha);
- the tourism zone (1 226.525 ha);
- the settlement zone (2 571.500 ha);
- the rehabilitation zone (122.154 ha); and
- the aquaculture zone (788.213 ha); and
- the traditional fishing zone (103 883.862 ha).[3]

The zoning was developed through numerous public consultations with local fishers' representatives from all villages in the KJNP. Yet, when interviewed during the case study, some local fishers from the four villages studied stated that they were not consulted about zoning proposals, especially the core zone, and many did not agree with the location and size of the core zone (Kumbang, Tanjung Bomang, Taka Malang and Taka Menyawakan Islands), which allegedly infringes on their fishing rights although it is clear that the largest zone is the traditional fishing zone. This zone allows fishers living in KJNP to fish there, as has been the case even before KJNP was established. However, the KJNP/MPA authority requires fishers to use environmentally-friendly fishing gear, such as the tonda, handline, longline, fishing rod, gillnet, *bubu* (trap) and spear gun, and has banned purseine boats.

The KJPN/MPA authority has forest rangers to monitor and enforce the law in KJNP. Some reported offences committed by fishers from both inside and outside KJNP include destructive fishing practices such as potassium and bomb fishing, illegal

[3] Ministry of Forestry. 2010. Directorate General Forest Protection and Nature Conservation, Balai Taman Nasional Karimunjawa. Report. Balai Taman Nasional Karimunjawa Statistic. pp. 10. (Available at http://storage.jak-stik.ac.id/ProdukHukum/kehutanan/stat_karimun07_0.pdf)

fishing gear/trawl operation (Ministry of Forestry, 2011:25). These destructive practices are generally prohibited in Indonesia according to Fisheries Law No. 31/2004.

In KJNP, besides the KJNP/MPA authority, there are the provincial marine and fisheries agency, the regency marine and fisheries agency, and a coast and sea police force. The provincial marine and fisheries agency provides a nursery for *kerapu* (grouper), and the regency marine and fisheries agency provides training for local fishers in seaweed farming and aquaculture.

Fishing practices

The Karimunjawa Islands are home to predominantly small-scale fishers, who often use hand and line techniques to catch pelagic and demarsal fish. Some fishers from Karimunjawa and Nyamuk villages use spear guns and compressors, and dive to catch fish in 20–30 metre-deep water, usually at night. Most of the fishers from Parang village fish outside KJNP, travelling up to 100 miles using GPS to catch high-value fish for export. In Karimunjawa village, 58 percent of the people are fishers, while in Nyamuk village 48 percent are fishers. Only Karimunjawa village is developed for tourism. Besides fishing, the people in these four villages rely on farming, trade and tourism for their livelihoods.

FIGURE 4
Local fishers about to land in the afternoon after fishing in Karimunjawa

Source: Photo courtesy of Laely Nurhidayah.

Conflict

Small-scale fishers can fish anywhere in the Indonesian fisheries management areas (Figure 1), according to Fisheries Law No. 31/2014, article 61(1). The traditional fishing zone in KJNP is exclusively reserved for people living inside KJNP, including the fishers in the four villages studied, according to the Ministry of Forestry Decision No. P. 56/Menhut-II/2006 on the Guidance of Zonation in National Parks.

Tensions arise between fishers living inside and those living outside KNJP (in the cities of Batang, Cirebon, Jepara, Pekalongan, Rembang and Tegal) who come to fish in KJNP, and use bigger boats and the *cantrang* net (mini trawl). Fishers from Jepara claim that they have rights to fish in KJNP because traditionally they have had access to fish in the area. Fishers in KJNP claim that some outside fishers take too many fish with destructive fishing gear, in particular the *cantrang* net and the compressor. Furthermore, the use of the *cantrang* net caused the loss of *bubu* fish trap stock, which the fishers in KJNP have had to replenish. Ministry of Fisheries Regulation No. PER.02/MEN/2011 on Fishing Line and Fishing Gear Uses in Fisheries Management Areas in Indonesia, allowed the use of the *cantrang* net only within a 4-mile radius of KJNP as it is a protected area. However, in practice fishers outside KJNP fish too close to KJNP. It should be noted that there is a general ban since 2015 by the Ministry of Marine Affairs and Fisheries Decision No. 2 on the use of the *cantrang* net as a form of destructive fishing gear.

Tensions also arise among fishers living within KJNP over the use of compressors and spear guns by some fishers, as it disadvantages those fishers who use hand and line techniques. The compressor is prohibited by Law No. 1/2014, amending Law No. 27/2007 on Management of Coastal and Small Island. To resolve the dispute over the use of this destructive fishing gear, and following an agreement between fishers who use compressors and those who use hand and line techniques, the community adopted a village regulation. The regulation states that fishers who use compressors are prohibited from catching *Sunuk Hitam* (*Plectropomus areolatus*) forever, and fishers who use compressors (with spear and gun) are prohibited from catching *Kerapu Batu* (*Epihephelus polyphekadion*) and *Kerapu Kertang* (*Epinephelus lanceolatus*) from 18 to 28 February and on the 18th to the 29th days of the months between November and March, according to the moon calendar.[4] Fishers who breach the prohibitions are to be fined between IDR 2 000 000 and IDR 5 000 000. Likewise, all fish traders/buyers are prohibited during those same periods from buying these types of fish from those fishers who use compressors.

Sustainable fisheries and livelihood security

The KJNP authority aims to achieve sustainable fisheries. Yet, fish numbers are decreasing as fishers living in KJNP still use destructive fishing practices. Even today, fishers from Parang village cannot sustain their livelihoods by fishing in KJNP, so they must fish outside KJNP. In addition, the effectiveness of the core zone is limited, as fishers fish in the area at night, and monitoring is subject to budget constraints.

Uncertainty around the regulation of fishing gear was resolved with the ban in 2015 by the Ministry of Marine Affairs and Fisheries Decision No. 2, on the use of the *cantrang* net and compressor, forms of destructive fishing gear, in the Indonesian fisheries management areas as well as in MPAs.

To achieve sustainable fisheries, the KJNP authority conducted several programmes in collaboration with NGOs, namely WCS and RARE. The Pride Campaign in collaboration with RARE works to raise awareness of the KJNP core zone location and of the benefits of the core zone to fishers living in KJNP so that they refrain from fishing there. Information is disseminated through mobile phones, using text messaging, and through marketing, using posters, calendars and t-shirts. The authority provides a hotline number to which local fishers can send text messages to report offenders. However, according to interviews with fishers in Karimunjawa village, they hesitate to report offenders who are neighbours or family members. The authority also marked the core zone by placing buoys around it. However, some of the markers have disappeared.

Another programme run jointly with RARE is Fish Forever, which establishes a territorial user rights in fisheries (TURFs) reserve in KJNP for fishers living inside the park. Meanwhile, the communities in KJNP have requested that the government provide them with livelihood options other than fishing and with capacity-building programmes, as they cannot depend during bad weather on fishing or tourism for income. Aquaculture presents an opportunity to diversify income and protect against market fluctuations in the prices of agricultural products (Lehane, 2013).

Food security

Fisheries and agriculture are the basis of communities' livelihoods in KJNP. However, fishers in the park have reported a decrease in fish catch, especially of small pelagic and demarsal fish in the waters around their villages (Fitriana and Adhuri, 2014). Furthermore, some fish species, such as lodi, parrot fish, little tuna and mackerel, are disappearing (Fitriana and Adhuri, 2014). This decline is due to overfishing and

[4] Karimunjawa Village Agreement, 28 October 2011.

destructive fishing practices by fishers living outside and inside KJNP and ultimately, this usurps the effectiveness of KJNP.

People living in KJNP are incentivized to fish outside the park, using modern technology such as GPS, and to limit the catch to high-value fish that yield greater income. Although this may sound beneficial for the KJNP, it challenges the implementation of the TURFs reserve dedicated to the park fishers, 50 percent of whom still fish outside park boundaries. The TURFs reserve will have to be redesigned to either absorb fishers excluded from the allocation of funds through alternative livelihood programmes or ensure that they do not fish outside the park (RARE, 2013). Young people living in KJNP fish outside the park because they feel there are no fish of value left in the MPA and thus the KJNP offers no benefit. Also, the communities in KJNP perceive the regulation that prohibits taking fish as well as other protected marine biota, such as turtle eggs, turtles and giant clams, in the core zone as a hindrance to accessing food.

Furthermore, seasonal monsoons prevent fishers in the park from going to sea and fishing far from their island/village from December to February. During the monsoon season, they usually fish around the Karimunjawa islands for their daily food needs. At this difficult time, the government usually makes rice available at lower than market prices to villagers through rice-for-the-poor programmes. Indeed, most monsoons bring huge tides of 2–3 metres which prevent the regular ferries and ships from Jepara from operating. When the delivery of food from Jepara to the Karimujawa Islands is disrupted due to bad weather, the government of Central Java province is usually forced to use warships to deliver food and transport people. Inhabitants of the Karimunjawa Islands depend on these supplies, and news sources have reported that they are threatened by starvation when isolated because of the monsoons (Detik News, 2008). However, during the interviews for this case study, the people of Parang village said that this is just media hype and there has been no starvation. Tourist activities also halt during bad weather, and some people in the tourist business choose to relocate temporarily to Java until the bad weather subsides. Thus, the high dependency of the communities in the park on fisheries and natural resources can result in tension between the communities and the KJNP authority.

MPA-FISHER INTERACTION IN THE MAYALIBIT BAY MARINE CONSERVATION AREA

MPA governance

The Mayalibit Bay MPA[5] with an area of 53 100 ha is part of the Raja Ampat Islands Marine Conservation Network,[6] West Papua, which totals of seven MPA networks 1,185,940 ha. The Mayalibit Bay MPA was established by Local Government Regulation No. 27 of 2008 on the Regional Conservation Area and is one of the five conservation areas in the Raja Ampat Islands Marine Conservation Network. The five conservation areas total 993,700 ha include: Area I, Ayau-Asia Islands (101 400 ha); Area II, Dampier Straits (303 200 ha); Area III, Mayalibit Bay (53 100 ha); Area IV, Southeast Misool (366 000 ha); and Area V, Boo and Kofiau Islands (170 000 ha). The other two MPAs, namely Sayang Wayag and West Waigeo, are part of the network but rather MPAs managed by the national government.

The Raja Ampat Islands administratively belong to the Raja Ampat regency, located on the northwestern tip of Papua in eastern Indonesia and lying within the Bird's Head Seascape at the heart of the Coral Triangle. The regency encompasses 4.5 million ha of ocean and includes 610 small islands and 4 main islands, namely Batanta, Misool, Salawati and Waigeo Islands.

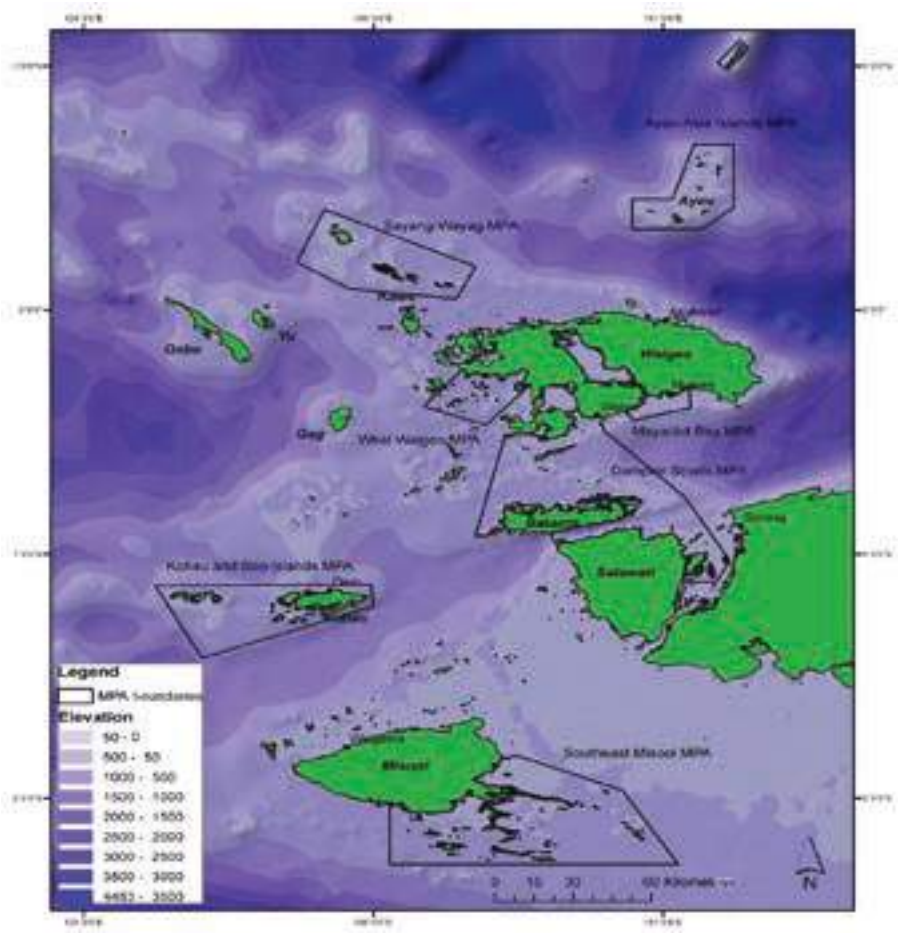
[5] *Kawasan Konservasi Laut Daerah* (KKLD) Marine Management Area (MMA).
[6] *Taman Pulau-Pulau Kecil Daerah* (TPPKD) Local Small Islands Park.

FIGURE 5 AND 6
Mayalibit Bay: Jetty with traditional boats in Kalitoko village and a local fisher arriving home from fishing in the morning in Go village

Source: Photos courtesy of Laely Nurhidayah.

Mayalibit Bay, a nutrient-rich, mangrove-fringed bay, has long been known as a feeding, breeding and nursery ground for fishes, and is home to a school of unidentified species of white dolphin (Seacology, 2007). A zoning system divided the bay area into a core zone, a limited use zone (subzone food security and tourism and subzone sustainable fisheries and culture) and one other zone (subzone *sasi* and traditional utilization and subzone other utilization).

FIGURE 7
Raja Ampat Marine Conservation Network, West Papua, Indonesia



Source: Agostini *et al.*, 2012.

The Mayalibit Bay MPA (Figure 8) was established in consultation with the fishers in the 11 villages on Mayalibit Bay and is managed by the local government (fisheries agency). Local Government Regulation No. 27 of 2008 also recognizes informal coastal management by local communities. CI was actively involved in the zoning, mapping and campaigning to promote the establishment of the MPA process. The fishers in some villages on Mayalibit Bay agree to the MPA authority's rules, particularly the rule prohibiting fishing on Saturday and Sunday, while fishers in other villages, especially Lopintol village, do not want to be bound by this rule. A number of fishers from Beo village also reject it, as they do not feel they benefit from conservation efforts.

The informal coastal management of Mayalibit Bay is by virtue of traditional tenure right. Each village has its own marine area, so fishers who fish in marine areas other than that of their own village must get a permit from the head of the village in whose marine area they fish, especially in the case of commercial fishers. This costal management also follows sasi practices, whereby certain areas are closed for fishing but reopen once yearly for a church anniversary celebration.

The Mayalibit Bay MPA is home to the 11 villages of Araway, Beo, Go, Kabilol, Kalitoko, Lopintol, Mumes, Waifoy, Warimak, Warsambin and Yesner (Figure 8). The seven villages that participated in this case study are Beo, Go, Kabilol, Kalitoko, Lopintol, Waifoy and Warsambin. Each of these seven villages has a population of around 22–70 households, whose livelihood depends on fishing, farming and collecting non-timber forest products.

FIGURE 8
Villages on Mayalibit Bay MPA, West Papua, Indonesia

Source: Adapted from Handayani *et al.*, 2016.

Fishing practices

Fishers in Lopintol and Warsambin villages catch *lema* (Indian mackerel) in their village marine area using the *balobe* method, while fishers inside the bay collect sea cucumbers using the *molo* technique. Among the 11 villages, the majority of the population in eight of the villages is Christian, so they refrain from fishing on Saturday and Sunday and participate in church activities. In the other three villages, the majority of the population is Muslim.

Conflict

There is no significant conflict with fishers living outside Mayalibit Bay, as the local *adat* law prevents them from fishing inside the bay, although, according to fishers of Warsambin village, fishers outside the bay area caught shark in 2000 in their village marine area. Before Mayalibit Bay became an MPA, trawl ship owners from outside the bay with permits obtained from people of Lopintol village, who live in Sorong, the capital city of West Papua province, came to fish in the Kalitoko village marine area. This created a conflict with fishers living in the bay area.

Conflict is possible among fishers living on the bay if some fishers set traps to catch crabs for commercial trade outside their village marina areas and do not ask for a permit

from the village in whose waters they set traps. This issue relates to tenure ownership of the marine area. Conflict can potentially also arise when fishers from a village do not obey the rule prohibiting fishing on Saturday and Sunday, with marked resistance of fishers from Lapintol village to this rule introduced by the MPA authority and CI.

Sustainable fisheries and livelihood security

Only fishers living on Mayalibit Bay fish in the bay, so there is no big threat of overfishing owing to fishers from outside the bay area fishing there. Fish is caught mostly for daily consumption, in keeping with economic subsistence. The fishers living on the bay use environmentally-friendly fishing gear (hand and line, scoop, *kalawai*, free dive). In the MPA, nets are prohibited and Local Government Regulation No. 27 of 2008 restricts large-scale fishing and commercial aquaculture. Furthermore, Local Government Regulation No. 9 of 2012 imposes fishing bans on sharks, manta ray and other ornamental fish species for the sake of sustainability.

Peoples' livelihoods depend on fishing, farming and collecting non-timber forest products. Villagers sell sago palm in Waisai, the capital of Raja Ampat regency, and in Sorong. Traders come to Beo, Go, Lopintol and Warsambin villages to buy fish from the local fishers, while in other villages on the bay fishers sell their fish locally.

Food Security

Most villagers around the Mayalibit Bay MPA are categorized as underdeveloped or "very left behind", because basic services are lacking. There is no main road to the villages, no area to conduct business activities and no market. There is a lack of schools, health facilities, telecommunication services, water and fuel (Indonesia Matters, 2006). The villages are very isolated and only accessible by boat. Indeed, residents find it more challenging to find food in rural areas such as those around Mayalibit Bay than in urban areas, where one can buy food from vendors. Food is directly sourced from the sea, small farms or forests. Refrigeration is not used to store food, because there is limited or no electricity, so people fish for their daily needs. Fish not consumed locally is either sold in the other villages or given away to neighbors and relatives. Given these conditions, for those people around conservation areas whose access to food and the means of livelihood are restricted, the local authority offers compensation, as allowed by Local Government Regulation No. 27 of 2008, article 16 on the Regional Conservation Area in the Raja Ampat regency. Furthermore, article 17 states that this compensation should be in a form that is in agreement with the community empowerment programme. However, according to a fisher from Beo village, the funding for community empowerment is primarily allocated to people outside rather than inside the bay.

DISCUSSION

Reconciling conservation and food security in MPAs

Integrating and reconciling priorities of conservation and food security in Indonesia is an immense challenge. MPAs are resisted by a large number of small-scale local fishers, whose livelihoods primarily depend on fisheries, which are an important source of income and food. In Indonesia, about 85 percent of fish products are consumed domestically, and the fisheries sector provides employment for about 6.5 million people (Indonesia Investments, 2014). Bans on fishing in certain areas, which were previously accessible to local fishers, restrict their access to food and a source of income, thereby jeopardizing their livelihoods. Allegedly, MPAs support food security by allowing overall fish production to increase and the spillover of fish from a NTZ to replenish the fish stock in unprotected areas (Foale *et al*., 2013:174). This replenishment takes a long time before the fishers in the MPAs experience the benefits. Unfortunately, fishers

think in short-term rather than long-term outcomes. For them, livelihoods and food security are more essential than conservation.

The lack of compliance by the local communities with the MPA's regime reduces its effectiveness. Some Indonesian fishers still fish in NTZs at night. Yet, in KJNP, for example, compliance with NTZs has improved by almost 40 percent since 2010 (Weigel *et al*., 2014:199). This is attributable to the active engagement of fishers and community members in the KJNP's management regime, by running joint patrols and a telephone hotline for reporting fishing violations. At the same time, in addition to KJNP's local rangers, the KJNP authority established a patrol partnership called *Masyarakat Mitra Polhut* (MMP) with park communities. The MMP recruits 10 to 20 people from each village to monitor and run joint patrols around Karimunjawa Island. The KJNP authority provides funding, safety jackets and fuel for the MMP's boat. The MMP actively patrols 24 hours a day during *tongkol* (mackerel tuna) season. In addition, a community surveillance group called *Pokwasmas* has been organized in all villages in the park by the marine and fisheries agency. However, the *Pokwasmas* is not as active as the MMP, as it receives less funding from the marine and fisheries agency (Bornstein, 2012). Best practice for the management of MPAs promotes inclusiveness and relations-building at the grassroots level.

To be effective, MPAs need the active participation of local communities from the planning stage of MPA creation to the mapping and monitoring stages. Top-down management approaches to MPAs undermine their conservation goals and overall legitimacy, marginalize vulnerable groups from marine governance processes and cause socio-economic harm by impacting on livelihoods and displacing tenure. Community support for the MPA comes when short-term gains are to be had.

FIGURE 9 AND 10
Mayalibit Bay: A Focus Group Discussion (FGD) in Go village and local community activities in Go village in the afternoon

Source: Photos courtesy of Laely Nurhidayah.

Historical data on the long-term benefits of the MPA for the surrounding fisheries is lacking. In order to reconcile conservation and food security goals, the government should compensate local people where catch areas are restricted, as occurred in the Raja Ampat regency, as provided for by Local Government Regulation No. 27/2008, articles 16 and 17, through the community empowerment programme. Some villagers in the Mayalibit Bay MPA complained that they did not benefit enough from the conservation efforts, rather people outside Mayalibit Bay benefited from the spillover of fish.

In the interests of best practice for marine management, it is widely recognized that MPAs should be "embedded in broader fisheries or spatial management frameworks" (Weigel, *et al*., 2014:199). These frameworks may take the form of integrated coastal zone management or an ecosystem approach, whereby the interactions between various components of the ecosystem are considered, such as the human and fish biomass

dimensions. If relevant agencies and their roles are coordinated and clarified around a broader fisheries management programme, the duplication of effort for regulation, surveillance and governance of the MPA is reduced, along with other benefits. Furthermore, MPAs in themselves are hardly effective tools for fisheries management. On the contrary, an isolated MPA will displace fishers and drive up fishing costs without actually alleviating fishing pressures. Coordination and legitimacy are the foundations for the best practice of MPA governance.

Another approach to MPA inclusion in the broader fisheries management framework is to provide alternative livelihood options and capacity-building programmes for fishers. Based on focus group discussion during these case studies, many fishers want governments to facilitate these programmes. Fishers in KJNP have demanded government support to improve technology for fishing and agriculture and to develop tourism by improving infrastructure and providing cheap public transportation by boat to not only Karimunjawa village but also to Kemujan, Nyamuk and Parang villages. Research shows that the success of MPAs for fisheries depends on factors such as good governance, a good understanding of ecology and serious efforts to improve socio-economic welfare. For example, Cabo Pulmo National Park in Mexico experienced an increase in fish biomass through effective enforcement of regulations, widespread community support for the MPA and economic opportunities for tourism in neighbouring villages (Weigel *et al*., 2014:1990. Hence, local communities can equitably share the costs and benefits of marine biodiversity and conservation.

From December to January when fishing is not possible due to seasonal monsoons, unemployed locals, who usually stay on Karimunjawa islands, need options for alternative livelihoods. In the Karimunjawa Islands, intermediaries and traders are important people because they sell the catches and loan money to villagers. Also, the government distributes subsidized rice to poor people in the villages for the sake of food security. In addition, the small grocery kiosks (traders) in the villages are a vital source of food for the fishers in KJNP and Mayalibit Bay. In KJNP, fishers stock up on food for the month but pay for it in the months thereafter, when they are paid for the catches. Yet, in Mayalibit Bay the most important sources of food for local people are still the sea, farm land and the forest.

Conserving marine ecosystems as well as addressing poverty and food security should be the main foci of local government, particularly in Mayalibit Bay. To do so, it is necessary to improve infrastructure and market access, as isolation from capital district centres means food diversity in the villages is lacking unless food is transported by boat, which is an expensive process. In response to this need, the development of a road infrastructure is underway. According to Presidential Instruction No. 34/2015 on Spatial Planning in Maluku province and West Papua province, a national road network will be established which includes the links Waisai-Warsambin, Wawiyai-Kabilol-Go,Yesner-Mumes and Wairemak-Yensner. It is expected that a multi-stakeholder approach (national and local governments) will contribute to poverty alleviation and at the same time address other areas of concern in Mayalibit Bay.

By creating a collaborative network of stakeholders that is not limited to government agencies, NGOs and civil society, diverse voices can create a discourse around strategies for marine management, and make a long-term commitment to both conservation and food security. In Belize, the Belize Fisheries Department formed a partnership with the Environmental Defense Fund, a non-profit organization, NGOs and fishers to explore the possibility of a managed access (MA) scheme for two pilot marine reserves. These partners established MA committees consisting of community groups which were selected to represent fishers and liaise with the government on the implementation of the MA scheme. This inclusive partnership has resulted in a dramatic decline in illegal fishing activity and the accreditation of over 200 fishers under a new management regime. The majority of fishers reported satisfaction with the MA scheme and called

for its expansion (Weigel *et al*., 2014:199). By contrast, in Thailand the Department of National Parks, Wildlife and Plant Conservation has been less successful in establishing local committees for the ongoing management of MPAs. For some participants, the committees were ineffective because they were largely comprised of regional business people and politicians, to the exclusion of local community representatives (Bennett and Dearden, 2014). When established using the proper criteria, multi-stakeholder partnerships can be accountable to local communities and at the same time empower them to meet the dual challenge of conservation and development.

Government law and policy

Government policy and regulations have a huge impact on fishers, particularly as concerns their fishing gear. In 2015, the government adopted yet another policy in favour of conservation and sustainable fisheries, namely the Ministry of Fisheries Regulation No. 1 on lobster, crab and blue crab catch and Regulation No. 2 on the ban of trawls and seine nets. For local fishers in KJNP, the ban on this destructive fishing gear is a relief. However, 200 000 fishers from Central Java who use the *cantrang* net may lose their jobs, and they lack other skills to make a living. Crew members on a boat where the *cantrang* net is used usually number around 35 so given the numerous crews, many jobs are at stake. Their livelihoods depend on the continued use of the *cantrang* net. Although this ban benefits small-scale fishers in the Karimunjawa Islands, it does not benefit fishers and traders in other areas. Generally, people in and around MPAs would benefit if local government regulation (Jepara) were to recognize the Karimunjawa Islands traditional territorial rights which exclude fishers outside KJNP from the park's traditional fishing grounds. In KJNP, lack of local government support for village regulation undermines the effectiveness of the latter.

Some of the Government of Indonesia's laws and actions dealing with food security include Food Security Act No. 18 of 2012 that outlines the importance of agriculture, fisheries, forestry and animal husbandry as varied sources of food. A significant focus of Indonesia's food security programme is on rice, which constitutes the major source of calories for most Indonesians. The law mentions food reserves at national, provincial and village levels, and community food reserves (trader, community and household). Food security is defined as a situation wherein an "individual" at all times has physical, social and economic access to sufficient, diversified, safe and nutritious food that meets her/his dietary needs, food preferences and religious beliefs, in order to have an active and healthy life.[7] Self-sufficiency in rice is a key policy for food security in Indonesia (Natawidjaja and Rum, 2013). Yet, in Papua, the main local food has been "sago palm", and only recently has rice become a staple.

Fisheries have not been the main focus for diversifying food security, which is evident from the fact that Indonesia's fish consumption per person is only 17.9 kg per year (FAO, 2004). By contrast, Japan's average per capita consumption of fishery products was 66.9 kg per year during 2001–2003, which is approximately four times the world average (FAO, 2004). Fish and other aquatic products provide at least 20 percent of protein intake for a third of the world's population, with the greatest dependence in developing countries (Beare, 2012).

Small-scale fisheries are by far most important for food security (Beare, 2012). Future policies and governance should focus on small-scale aquaculture as a means of alleviating poverty and improving food security (Lehane, 2013). Recently, the Ministry of Fisheries has implemented a pilot project called Fisheries Aquaculture for Food Security in Indonesia (Fafi). The Fafi project aims to increase the availability and accessibility of safe and good-quality fish and fish products on the domestic market in Indonesia. Indonesia adopted the international Voluntary Guidelines for Securing

[7] Food Security Act No. 18 of 2012 Art 1 (4).

Sustainable Small-Scale Fisheries into a draft National Plan of Action on Small-Scale Fisheries (NPOA-SSF), and has already incorporated it into the Long-Term National Development Plan (RPJMN 2015–2019). The RPJMN states that the government should provide credit facilities for small-scale fishers, and subsidies and insurance. In addition, Indonesia's House of Representatives has enacted legislation on small-scale fisheries, small-scale aquaculture farmers and salt farmers with Law No. 7/2016. The legislation covers: planning, protection measures (e.g. infrastructure development, fuel subsidies, work contracts, insurance), capacity measures, funding and financing, monitoring and community participation.

Arif Satria, a lecturer from the Institut Pertanian Bogor (IPB), suggested that there be legislation to cover small-scale fishers' access to food, education, health, land and housing (Satria, 2015). Also, legislation should be enacted to regulate wages, insurance and credit for small-scale fishers. Rokhmin Dahuri, former Minister of Maritime Affairs and Fisheries of Indonesia, suggested that there be legislation covering the obligation of government to provide alternative livelihoods to compensate for the three to four month period when fishers cannot operate due to the monsoons (Media Business, 2015). Even though not all the suggestions from these and other experts have been legislated, indeed, Law No. 7/2016 brings hope to small-scale fishers that they will have better food security and will be able to improve their livelihoods.

CONCLUSION

An MPA is a marine area dedicated to the protection of biodiversity, as well as natural and associated cultural resources, and managed through legal or other effective means (Commonwealth of Australia, 2013). One of the benefits of MPAs is a reversal in the decline of fish populations in local areas through the protection of critical feeding, breeding and nursery habitats. Nonetheless, in the KJNP case study, fishers reported a decrease in catches and no spillover of fish from the KJNP MPA to surrounding areas. Furthermore, the MPA is ineffective when fishers use the NTZ at night and when NTZs are too small in comparison with the total area of the MPA. The ineffectiveness of MPAs lends to the belief that MPAs have limited advantages for locals, and even negative effects on their livelihoods. Some fishers in the Raja Ampat Regional Conservation Area share these sentiments, as fishers outside the area benefit from the spillover of fish from the Mayalibit Bay MPA. In one village, fishers are reluctant to be bound by the local government's regulations.

Conservation of marine biodiversity through MPAs should be integrated with the need to improve the well-being of fishery communities. The effectiveness of the MPA demands that all stakeholders, particularly local fishers, be involved in the planning, mapping, implementing and monitoring of the MPA. Likewise, all fishers in the MPA should share the benefits. Yet, considerable tension exists between those who prioritize conservation or food security in Indonesia, and those who, like the huge number of small-scale local fishers, give priority to ensuring their livelihoods, which depend on fisheries, and who resist the creation of MPAs and MPA regulations. Compensation through community empowerment programmes, improved infrastructure and government support for small-scale fishers to pursue alternative livelihoods are all necessary for reconciling the two priorities. Awareness-raising campaigns would also help to increase understanding and raise the support of communities for MPAs. The keys to sustainable fisheries are the use of environmentally-friendly fishing gear, limited access and limited catch (Commonwealth of Australia, 2013). Rights-based fishing, such as the TURFs reserves, is currently scheduled for implementation in both the KJNP and the Mayalibit Bay MPAs. With recognition of local regulations that support TURFs reserves, which would exclude fishers from outside the MPAs from using traditional fishing grounds, local government legal frameworks would increase benefits for local people living in and around MPAs.

Certainly, government policy and regulation can make a huge contribution towards supporting sustainable fisheries and food security, even though disadvantaged fishers protest measures. Both Ministry of Fisheries Regulation No. 1 of 2015 on lobster, crab and blue crab catch and Ministry of Fisheries Regulation No. 2 of 2015 on the ban of trawls and seine nets favour conservation and give advantages to small-scale fishers. The adoption of Food Security Law No. 18/2012 by the Government of Indonesia is a first step towards making sustainable fisheries the main focus of efforts to diversity food security. Consideration for small-scale fishers and aquaculture should guide future policies and governance strategies of the Indonesian Government, in order to alleviate poverty and improve food security in a sustainable and equitable manner. Only strong governance and management processes with an emphasis on grassroots participation, coordination and accountability will result in effective MPAs that foster a dual conservation and food security mandate.

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Analysis of small-scale fishery development within Costa Rica's MPA system

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BACKGROUND/PURPOSE

Costa Rica is considered one of the 20 most biodiverse nations in the world. The country's diminutive size (51 100 km2) is further dwarfed by an exclusive economic zone (EEZ) over ten times larger (613 683 km2) than its land mass. Within the EEZ, an estimated 7 000 marine species (approximately 3.5 percent of the world's marine biodiversity) can be found (Wehrtmann and Cortés, 2009). This expansive area is comprised of high seas and coastal ecosystems, including coral reefs, mangroves, a tropical fjord, an oceanic trench up to 4 000 meters deep, a seasonal upwelling area, an oceanic thermal dome, a submarine mountain range (Cocos Ridge), multiple coastal islands, and one oceanic island (Cocos Island) (Nielsen-Muñoz and Quesada-Alpízar, 2006; Cortés, 2007; Wehrtmann and Cortés, 2009).

Costa Rica's marine areas maintain the country's small-scale fisheries (SSFs). These areas also provide critical habitat for charismatic marine species, including whales and sea turtles, which contribute heavily to the country's robust tourism industry (La Nación, 2014). For this reason, the country developed a system of coastal marine protected areas (MPAs) to conserve their endangered populations. Management of these areas was exclusively administered by the National System of Conservation Areas (SINAC), a decentralized branch of Costa Rica's Environmental Ministry (MINAE). It began with the creation of both no-take and multiuse MPA extensions of established terrestrial parks and/or reserves along both the Pacific and Caribbean coasts (SINAC, 2012). In 2008, two management area categories, marine reserves and marine management areas, were established to accommodate varying levels of recreational and extractive activities (SINAC Executive Decrees 34433, 35369). Marine reserves permit the sustainable extraction of the area's resources through the use of low impact artisanal fishing gear types. Marine management areas allow for larger-scale fisheries to operate, including the surface longline fishery, as well as for permanent structures, including marinas, to be built (Rodríguez-Chaves, 2011). The objective of these two categories is to promote responsible resource use, education, scientific research and monitoring. While their establishment represents a paradigm shift in Costa Rica from marine fauna protection to managed resource exploitation in order to support coastal fishery development, the country has struggled to develop the governance tools needed to establish and manage these new areas.

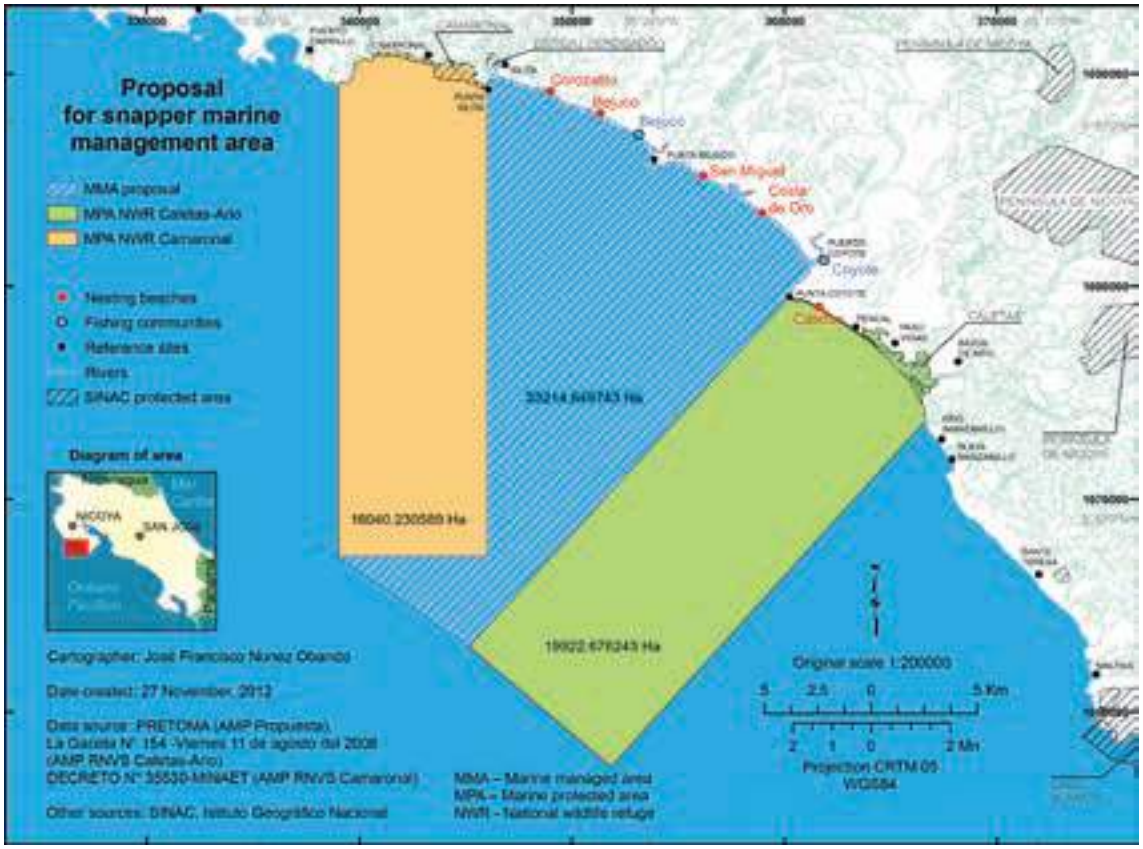
In response to this situation, the Costa Rican Fisheries and Aquaculture Institute (INCOPESCA), Costa Rica's national fisheries governing entity, created its own

category of managed areas called responsible marine fishing areas (RMFA) (La Gaceta, 2009). The RMFA strategy was designed to recognize coastal community organizations for their role in SSF governance (Fargier, Hartmann and Molina-Ureña, 2014). The RMFAs are based on the Food and Agriculture Organization of the United Nations' (FAO) Code of Conduct for Responsible Fisheries and are intended to be a zoning instrument that regulates SSF activities within a designated area (FAO, 1995; La Gaceta, 2009).

A Presidential Commission on Marine Governance was established in Costa Rica, comprised of representatives from various government ministries and institutes, with a short-term objective to analyse the effectiveness of Costa Rica's marine governance structure, and a long-term objective to develop a marine spatial planning strategy for the country. The commission in turn established a Council for the Seas (CONAMAR) with a role within the commission to develop a national marine policy and conservation agenda. Its analysis of Costa Rica's marine governance framework was the first step towards this goal. The result was an assessment that the current marine management strategy is considered to be arbitrary, fragmented and not always based on a sufficient incorporation of scientific and social information (CONAMAR, 2013). Shortly after finalizing and releasing the policy and conservation agenda in 2013, CONVEMAR and the Commission were dissolved during Costa Rica's political regime change in 2014. Little has been done since CONAMAR's findings to improve the efficiency of the country's coastal management structure.

FIGURE 1

Location of two SINAC managed multi-use MPAs and a proposed third managed area within the Bejuco bottom-longline snapper fishery's fishing grounds



An example of coastal resource management shortcomings can be seen in the district of Bejuco, Guanacaste, along the country's northern Pacific coast. Small-scale fishers in Bejuco catch spotted rose snappers (*Lutjanus guttatus*) with demersal bottom longlines during nightly voyages not exceeding 3 km from the coast. The impoverished community (INEC, 2013) fishes between two multiuse MPAs. Both MPAs were developed to protect nesting populations of olive ridley sea turtles (*Lepidochelys olivacea*) from unselective gear types, including shrimp trawl nets, gillnets and surface longlines, while allowing more responsible artisanal gear types to be used, including bottom longlines. The Bejuco fishing community was not consulted during the political MPA design process and the MPAs were established in areas outside of its primary fishing grounds. While the MPAs protect the local sea turtles (Adams, López and Arauz, 2014), their effectiveness at stopping destructive fisheries from targeting the locally important snapper stock is less understood (Bystrom, 2015).

Concerned with the Costa Rican Government's inability to adequately manage coastal resource extraction activities, national and international NGOs, including the Sea Turtle Restoration Program (PRETOMA), the Costa Rican Environmental and Educational Network (ARCAE) and Conservation International, in addition to the University of Costa Rica and Costa Rica's National University, are working with Bejuco bottom longline fishers to design and implement sustainable coastal development strategies (Bystrom, 2015). One of the focuses of this work is to analyse the effectiveness of Costa Rica's marine resources management system, as well as the various protected area strategies it has created in order to improve fishers' livelihoods and food security strategies in SSF communities.

TRANSDISCIPLINARY RESEARCH TO DEFINE FISHING COMMUNITY DEVELOPMENT STRATEGIES

Decades of extraction activities in the absence of traditional stock assessments and effective management strategies have led to the overexploitation of renewable marine resources through overfishing and habitat destruction from destructive fishing methods (Bystrom, 2015). Being one of the most fished species by small-scale coastal fishers throughout Central America, the spotted rose snapper is of high economic importance, if not the highest importance, to artisanal fishing communities in Costa Rica (González *et al*., 1993; Rojas, 1996; Rojas, Maravilla and Chicas, 2004; Bystrom, 2015). In order to protect the local snapper stock and to improve fishers' livelihoods, conservationists and researchers from PRETOMA and ARCAE have collected and analysed fishery catch data and social information in the form of fisher ecological knowledge (FEK) from the three Bejuco bottom longline snapper fishing associations whose activities occur in and around the area's two multiuse MPAs.

Fishery catch data has been continuously recorded since July 2007 through both landings and onboard observations. Fishery data includes total snapper lengths and weights, sex, reproductive state, a record of all bycatch species, lengths and weights of commonly caught bycatch species, fishing locations, depths, and bottom longline characteristics (line length, number of hooks, hook size). The analysis of this data has allowed researchers to determine snapper population dynamics (weight/length comparisons, growth curves, mortality estimates, recruitment, age at first reproduction, average snapper lengths, snapper catch per unit of effort). Bottom longline selectivity and bycatch composition have also been calculated and identified.

FEK regarding fishers' socio-ecological perceptions was collected through a survey applied to the entire population of Bejuco bottom longline fishers (49 individuals). In addition to this information, focus groups and individual interviews were also conducted. The qualitative information collected through this study was used to determine fishers' opinions regarding their present livelihoods as well as future livelihood scenarios, the role that the fishery plays in local food security issues, the effectiveness

FIGURE 2
Bejuco bottom-longline fisher landing data collection, northern Pacific coast, Costa Rica

Source: Photo courtesy of PRETOMA-ARCAE.

of bottom longline use, and their views on sustainability and governance, and to historically reconstruct the fishery's production in order to understand its tendencies in the years before quantitative catch data were collected.

Results from the investigation of snapper population dynamics, and bottom longline catch composition and selectivity, and the survey on FEK of the Bejuco fishery were analysed within three major subsystems (Charles, 2001) – natural, human and management – and compared to the results from similar studies identified in multiple independent publications, using the traffic light method (Caddy, 1998) to denote trends in the study's results (green, yellow, red). A series of indicator-based management recommendations were then developed for each of the fishery's subsystems based on these results.

RESULTS

Among the study's most notable results, average snapper lengths have significantly increased, while there was no significant change in the fishery's catch per unit of effort. Slightly over half of the fishery's total catch is snapper, and nearly 100 other species are caught on bottom longlines. Many commonly captured bycatch species (between 20 and 30 percent of the entire catch) are retained and consumed locally by fishers and other community members. In this regard, the Bejuco fishery demonstrates characteristics of a subsistence fishery in the way communities rely on a portion of the fishery's production for self-consumption (García and Rosenberg, 2010). In this light, protection of not only the snapper stock, but also bycatch species is crucial

FIGURE 3
Spotted rose snapper (*Lutjanus guttatus*) caught with bottom-longlines in the district of Bejuco, northern Pacific coast, Costa Rica

Source: Photo courtesy of PRETOMA-ARCAE.

for the continued development of this fishery, its members' livelihoods and community food security.

Fishers' socio-ecological perceptions revealed that while 92 percent of bottom longliners have a high quality of life in their communities, 96 percent of fishers are concerned for their future economic livelihoods, and believe there will be fewer snappers in the future to sustain their way of life. Furthermore, 84 percent of fishers feel that their earnings from the snapper fishery no longer allow them to adequately meet the financial needs of their households. The population also feels that while bottom longlines are an effective way to catch snappers, catch totals have decreased over the last ten years. Despite this concern, 90 percent of the Bejuco population asserts that it will continue to use bottom longlines in the future to fish for snapper. Fishers, while in agreement that the area's MPAs have helped to reduce semi-industrial shrimp trawler activity, remain concerned over the continued instances of illegal fishing by this fishery within the protected areas.

The development strategy includes a campaign to create a new managed area (the exact category remains to be defined) located between the existing MPAs, and the development of a local bottom longline sustainability strategy that could serve as the basis for a community-based fishery management system for this area. In addition to these measures, fisher workshops were developed with university researchers, local buyers (intermediaries), attorneys and business administration experts in order to strengthen their capacity to self-organize and consolidate their fishery into one all-inclusive association capable of managing the snapper supply chain in a transparent manner. A Marine Stewardship Council (MSC) sustainability certification campaign for bottom longline caught snappers was also begun, as a means of protecting the resource, ensuring its long-term productivity and contributing to local food security issues and therefore fishers' quality of life.

DISCUSSION

Effectiveness of MPAs and managed areas as management tools for the conservation of fisheries resources

The roles that MPAs, marine reserves, marine management areas, and RMFAs in Costa Rica are playing – and will play in the future – heavily impact food security and sustainable livelihoods benefits in the country's SSF communities. Currently, few criteria or technical studies have contributed to the establishment of these areas. The isolated biological resource monitoring studies that did shape their development primarily focused on coral reefs, fish populations, whales and dolphins, and turtle nesting sites developed by government agencies, universities, NGOs and volunteers (Alvarado *et al.*, 2012), and involved few, if any, actual fisheries in the planning process. Additionally, insufficient financial, human and material resources have been allocated to these areas by the national government to appropriately confront a growing list of threats, including overfishing, illegal fishing and coastal alteration (tourism development) (Alvarado *et al.*, 2012). Contributing to these management challenges, SINAC does not observe co-management or community-based natural resource management strategies. According to Charles (2011), a governance gap such as this one will inhibit fisher-led actions aimed at improving the adaptive capacity of the fishery from being recognized. In this regard, SINAC's MPA management strategy exemplifies Costa Rica's dominant governance paradigm, one whereby protected area management is heavily centralized and top-down, and has traditionally given little, if any, local management power to local governments and communities (Larson, 2003; Fargier, Hartmann and Molina-Ureña, 2014).

In theory, INCOPESCA's RMFAs strive to create better economic options for fishers (INCOPESCA, 2008). However, the reality is that RMFAs are established

without sufficient technical justification, only taking into account areas where certain artisanal fishing techniques are applied and have resulted in user rights conflicts between fisheries (Bystrom, 2015). And like SINAC, INCOPESCA's SSF management strategy does not overtly recognize co-management systems, though some SSF communities have developed local monitoring systems, not formally recognized by INCOPESCA, intended to thwart illegal fishing efforts. Strategies such as these are spurring SSF community interest in the development of such areas where their fishing activities occur.

The Bejuco snapper fishers are included in this movement, spearheading a campaign to create a new managed area that would include the entire unprotected area they currently fish in, as well as link the existing two SINAC MPAs to form one large protected zone. There is interest in petitioning INCOPESCA to develop an RMFA in the area, though the omnipresent lack of financial and human resources in both INCOPESCA and SINAC does not allow any managed area to operate with enough personnel to implement a full management plan (Alvarado *et al*., 2012). Local fisher co-management strategies could relieve some of this pressure, but it is unclear if such systems of governance for marine areas will be officially recognized in Costa Rica in the near future.

Aware of these shortcomings, the Costa Rican Government held a national SSF workshop in November, 2013, to better define the challenges and opportunities associated with the development of MPAs and RMFAs. During this process, fishers compiled a list of ten actions necessary for the effective development, implementation and management of these areas (Defensoría de los Habitantes, 2014). The following is a list of these actions as well as an update on their status:

1. Eliminate coastal illegal, unreported and unregulated (IUU) fishing and trawl net use.

   The Costa Rican Government's capacity to control instances of IUU fishing is and will in all likelihood be insufficient for the foreseeable future. Recognizing the environmental damage that the semi-industrial trawl fleet causes to the country's coastal ecosystems, the Costa Rican Supreme Court (Sala Cuarta) declared shrimp trawling activities illegal in 2013. Boat owners with valid licenses can still conduct fishing activities until those licenses expire, but since expired licenses can no longer be renewed, the fleet is undergoing a phase-out and will cease all operations in 2019. These moves could be changed, however, as a result of legislative initiatives in the Legislative Assembly to reinstate the fishery, on the basis that it will be managed sustainably.

2. Develop certification (including supply chain certification) strategies for products caught within responsibly fished areas that increase product value and traceability.

   The Bejuco snapper SSF is the only fishery in Costa Rica to apply for an international sustainability certification from the Marine Stewardship Council (MSC). Other SSFs are working with NGOs to develop local traceability certifications for artisanal caught seafood products.

3. Develop alternative employment opportunities for fishers.

   On a national basis, little has been accomplished on this subject. On a local level, a small number of artisanal fishers whose fisheries are located within high volume tourism areas work as boat captains, though obtaining the proper licenses to work in the tourism industry is difficult for most SSF fishers.

4. Develop strategies that promote active participation by local community members in the RMFA management process (co-management strategies).

   Very little, if any, progress has been made to develop co-management strategies in protected areas and RMFAs. Some SSF communities adjacent to RMFAs have purchased boats and motors for the purpose of patrolling their areas, but these fishers still have no official authority to do so.

5. Strengthen SSF representation within INCOPESCA's board of managers.

   There is now an SSF representative on INCOPESCA's nine member board.

6. Improve mechanisms for education and awareness-building among RMFA users and their related coastal community members.

   Over the last few years, more RMFA boundaries have been marked with a buoy system that both provides awareness of the areas' boundaries and aides in illegal fishing conflict resolution.

7. Integrate governmental institutions for the protection, monitoring and control of RMFAs and their successful operation within established legal frameworks.

   Very little has been accomplished. While some coastal communities have acquired patrol boats to attenuate instances of illegal fishing inside RMFAs, the coast guard is the only government entity with the authority to approach and arrest illegal fishers. Though INCOPESCA is the government institute charged with managing Costa Rica's fisheries resources, it has no on-the-water authority.

8. Establish RMFAs based on studies that guarantee their scientific, legal and social viability – including integrated mechanisms that build awareness for their successful management – that promote ecosystem health for the benefit of all stakeholders.

   Despite multiple coastal community petitions to INCOPESCA to establish RMFAs, the institute has acknowledged its capacity shortcomings in terms of its ability to manage the existing areas and has stopped creating more of them for now.

9. Foster scientific research (ecosystem and social) with the objective of developing a fisheries management plan that promotes the sustainable use of the resource.

   INCOPESCA continues to support graduate-level research in various RMFA communities that is used as a basis for resource monitoring, though no area has dedicated staff that monitor the catch and perform stock assessments.

10. Ensure minimum size limit (for individual species) control at all post-harvest stages along the supply chain, especially at local landing sites where products are first exchanged between fishers and buyers.

    In November 2015, INCOPESCA contracted the University of Costa Rica to estimate sizes at first maturity for six commercially important coastal fish species. The results of this one-year study can help to determine these species' minimum size limits.

MPAs and managed areas and the roles they play in providing food security and livelihood development opportunities: the Bejuco SSF case study

Despite the management challenges associated with MPA and RMFA governance in Costa Rica, the Bejuco bottom longliners are moving forward with their campaign to pressure the government to create a new management area that covers 100 percent of their fishing grounds. While the exact impacts of the existing two MPAs are not known, bottom longliners might be the beneficiaries of the spillover effect, and the development of a more comprehensive protected area could improve the probability that Bejuco's snapper stock will show signs of replenishment in the future (Bystrom, 2015). In fact, Stobart *et al.* (2009) showed how the spillover effect from 8 to 16-year-old MPAs, where fishing activity had ceased, resulted in mean body size increases in a variety of species. These studies support the hypothesis that the observed size increase of snappers might be related to the establishment of the Bejuco MPAs. However, as they were established in 2006 and 2010, the time span since the creation of these reserves might still be too short in order to assure such a relation. Marine systems are also complex entities and other factors could be influencing snapper size, such as environment-induced factors or genetic variability in life history characteristics, predator/prey relationships or competitive interactions (Shin *et al.*, 2005).

While a multitude of factors could be influencing snapper life history characteristics both inside and outside of the area's MPAs, and a stock assessment is still needed to better understand the status of this population, an increase in managed area coverage and comprehensiveness would certainly benefit the local SSF communities' initiatives to extract both snapper and bycatch resources using low impact gear types and thus increase the likelihood of food security and economic well-being in these communities. Looking forward, governance improvement in these areas is the next logical step towards further resource conservation. This, however, is not only challenging but will be limited by the reluctance of governmental agencies to create more managed areas, due to their institutional capacity concerns.

Fishers' dedication to maintaining their way of life and to fishing snappers with bottom longlines in the future makes the implementation of development improvements of upmost importance. Fishers have approved a locally-based sustainability strategy as a means of demonstrating their dedication to conserving the resource. While not formally recognized by SINAC or INCOPESCA, they hope this will serve as the first step towards their communities' increased role in the management of the local snapper stock. A local management plan is also a prerequisite for MSC certification. The Mexico Baja California red rock lobster (*Panulirus interruptus*) fishery has successfully used the MSC standard to secure government funding for infrastructure improvements, as well as its support for the ongoing development of a vast extension of geographically defined management areas – territorial use rights in fishing (TURFs) – that belong to the fishery's cooperatives (Cunningham, 2013). Bejuco fishers hope that MSC certification (if successful) will bring similar improvements. Moreover, this development strategy is designed to, in a governance system that does not recognize local management initiatives, force the government to more effectively manage the area's MPAs, develop a more inclusive managed area, strengthen political representation of the SSF sector and ultimately recognize the role that these communities are playing in the sustainable development of their fishery.

CONCLUSIONS

Costa Rican MPAs were first established as marine extensions of their well-established terrestrial parks and wildlife refuges. As marine conservation policy evolved, it became evident that these areas, while important tools for the protection of critical habitat for charismatic marine species, were poorly designed to sustainably manage the country's SSFs. In what could be deemed as a race to attend to fishing community concerns and needs, a type of sectoral coastal management system took shape. SINAC has developed multiuse MPAs, marine reserves, and marine management areas that permit a varying level of fishery development therein, while INCOPESCA has developed a system of RMFAs that is designed to benefit artisanal fisheries in specific communities. Both marine governance systems have adapted to better include fishers in the design and implementation process, but both lack co-management governance structures that allow local communities to absorb some of the monitoring and control responsibilities. Because of serious capacity shortcomings, no expansion of either SINAC's or INCOPESCA's marine governance programmes is anticipated in the near future, despite several community petitions to assist in the development and management of such areas. One example of these petitions is in Bejuco where fishers desire to create a more comprehensive managed area that links the existing multiuse MPAs. Such a system, if managed correctly at both the local and national levels, could significantly contribute to the conservation of a number of near-shore fish species important for coastal community food security and economic well-being. Because of the importance of the country's SSFs, it is essential for Costa Rica to continue to work through the growing pains it is experiencing in order to develop its evolving marine management system.

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Establishing freshwater protected areas to protect biodiversity and improve food security in the Philippines

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INTRODUCTION

Wild-caught freshwater fish is an important source of food in the Philippines (Briones, Dey and Ahmed, 2004; Fernandez-San Valentin and Berja, 2012). Particularly the rural poor depend heavily on inland fisheries (Kent, 1997; Dey *et al*., 2007). However, freshwater fish stocks in the Philippines are declining alarmingly, which threatens to aggravate food insecurity of already vulnerable households (BFAR, 2005). Overexploitation, invasive species, pollution and rapid land-use transitions have led to a severe decline in freshwater biodiversity (Kottelat and Whitten, 1996; Dudgeon *et al*., 2006). Freshwater wetlands are the most degraded ecosystems of the Philippines (DENR and UNEP, 1997). Endemic freshwater fish species are highly threatened (de Silva, Abery and Nguyen, 2007). Waterbirds are facing similar pressures (van Weerd and van der Ploeg, 2004a). The Philippine crocodile (*Crocodylus mindorensis*) perhaps best symbolizes the state of freshwater ecosystems in the archipelago. With less than 250 mature individuals surviving in the wild, this endemic species is classified as critically endangered on the IUCN Red List (van Weerd, 2010). The Philippine crocodile might well be the first crocodilian that will go extinct as a result of anthropogenic activities.

Unfortunately, little is done to address these problems. Policy-makers tend to undervalue the importance of wild-caught freshwater fish as a source of food for poor rural households (Dugan, Dey and Sugunan, 2005; Andrew *et al*., 2007). The Department of Agriculture for example, the mandated government agency for fisheries management, focuses mainly on marine fisheries and commercial aquaculture (Green *et al*., 2003). Similarly, the value of freshwater ecosystems is often overlooked (Darwall *et al*., 2008). Wetlands are poorly represented in the Philippine national protected

area system (PAWB, 2013). Moreover, the Department of Environment and Natural Resources lacks the capacity and resources to enforce environmental legislation on the ground (World Bank, 2003). Solutions for the Philippine freshwater biodiversity crisis, therefore, have to be found at the grassroots level.

This paper describes the efforts to establish a network of community-conserved areas in the municipality of San Mariano on Luzon, with the dual aim to protect the Philippine crocodile and to improve inland fisheries. The necessary steps to establish a community-conserved area are summarized, and their sustainability assessed. The importance of local leadership and democratic decision-making processes in the design of community-based conservation measures is highlighted, and it is argued that implicit cultural values, such as hospitality and respect, are often a more important motivation for rural communities to protect aquatic resources than explicit concerns about food security and livelihoods.

PROJECT AREA

San Mariano ranks among the poorest municipalities of the Philippines: 60 percent of the population lives on less than US$2 per day and 18 percent of children below ten years of age is malnourished (LGU San Mariano, 2010). Wild-caught freshwater fish forms an important, but undervalued, source of food for rural households. Table 1 provides an overview of the most common fish species in this remote area. Nile tilapia (*Oreochromis niloticus*), introduced in the Philippines in 1972, is by far the most commonly caught species. Catch data from eight villages in San Mariano show that as much as 85 percent of total yield is derived from introduced fish species (Engelhart, 2009). This is an indication of the unprecedented ecological changes that Philippine freshwater ecosystems have undergone over the past 70 years. Native species such as Giant mottled eel (*Anguilla marmorata*) are highly valued by fishers but have largely disappeared from most rivers. Freshwater shrimps (*Macrobrachium lar*) have also become rare.

FIGURE 1
Poor households depend heavily on wild-caught freshwater fish

Source: Photo courtesy of Jan van der Ploeg.

People use a variety of fishing methods to catch fish: traps (*bubu*), fykes (*bukatot*), hooks (*baniit*), harpoons (*panna*) and nets (*sigay*). Spearfishing is the most common method. In more turbid waters, people use dragnets or throw nets (*tabukol*). Nets are generally the most effective fishing method in terms of catch per unit effort, but require a substantial capital investment. In shallow rivers people build large fish traps of stones or bamboo (*sarit*). Rice fields and ponds are regularly drained to harvest fish by hand (*makkammil*).

In most villages there are no rules limiting access or prohibiting specific fishing methods: fishers can catch anything, anywhere, with any method and as much as they like. To catch large amounts of fish people make bombs out of old gin bottles, fertilizer and kerosene, and then detonate these bombs underwater (*babantu* or *bung bong*). People also use 12-volt batteries to stun fish and shrimps at night (*kuryente*), or use

pesticides to poison fish. In theory, these destructive fishing methods are prohibited by law (Fisheries Code of the Philippines – Republic Act 8550). But in practice the rule of law means very little in these remote, rural areas: in many villages, dynamite is openly used when people need a lot of fish, such as during funerals, feasts or the end of the Lent season.

Most people in San Mariano fish for subsistence, or barter wild-caught fish with other people in their village. There is little information available on the importance of freshwater fish in local diets. Exploratory research suggests that wild-caught freshwater fish provides on average 12 percent of daily protein intake of rural households, based on 8.3 grams per person per day (van Velzen, 2013). Especially poor households rely heavily on this "free" resource, in some cases providing as much as 30 percent of daily protein intake.

The freshwater ecosystems of San Mariano harbour a rich variety of wildlife, including the Philippine crocodile. Previously thought to be extinct in the wild on Luzon, a small and fragmented population was discovered in the municipality in 1999 (van Weerd and van der Ploeg, 2004b). In 2003, the Mabuwaya Foundation was founded to protect the iconic species in the wild (van Weerd and van der Ploeg, 2012). Five breeding sites were identified in the municipality: Dicamay River, Dinang Creek, Disulap River, Dunoy Lake and Narra Lake (indicated in green in Figure 1). An intensive education campaign has successfully stopped hunting of the species, but the reclamation of wetlands and the use of destructive fishing methods continue to pose a significant threat to the Philippine crocodile population in San Mariano (van der Ploeg *et al*., 2011a; Cureg *et al*., 2016).

Over the past ten years, the Mabuwaya Foundation has aimed to establish a network of freshwater protected areas (PAs) in San Mariano. The underlying idea is that these freshwater PAs can simultaneously protect crocodiles and improve food security of the rural poor: the creation of a no-take zone allows fish stocks to recover, thereby increasing overall yields (Leisher *et al*., 2010). This "spillover" effect has been demonstrated in several marine PAs in the Philippines, which have since then proliferated in the archipelago (Pollnac, Crawford, and Gorospe, 2001; Alcala and Russ, 2006). Very little is actually known about the dynamics, productivity and resilience of wetlands in the Philippines, but the creation of a freshwater PA seems a wise precautionary step (Johannes, 1998; Suski and Cooke, 2007).

TABLE 1
Most commonly caught freshwater fish species in the municipality of San Mariano

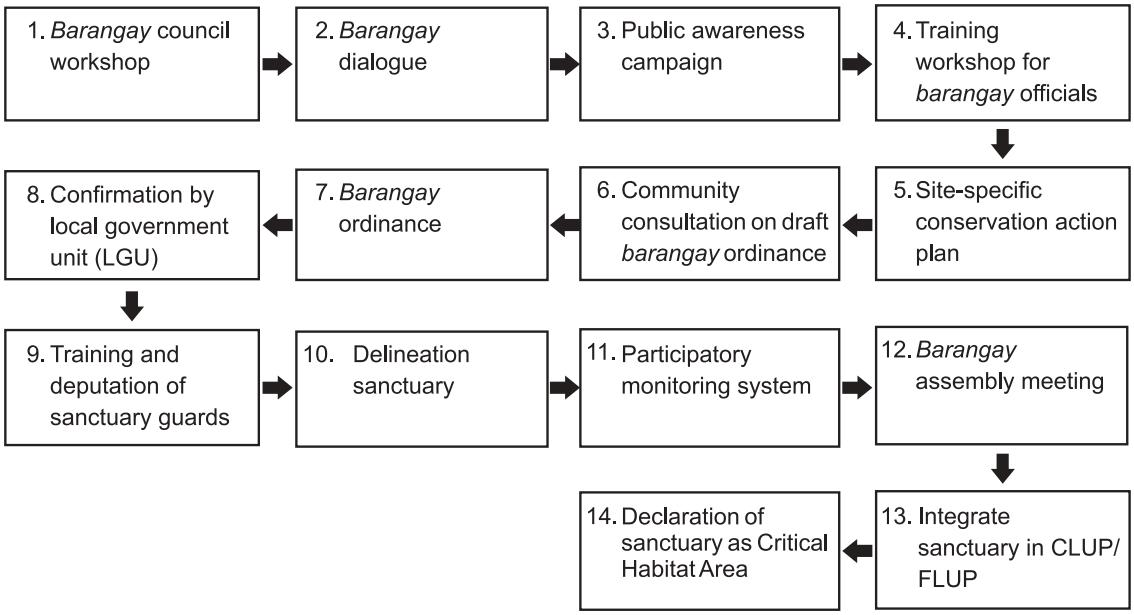
Scientific name	English name[1]	Ilocano name	Origin[1]	Percentage of total catch[2]
Oreochromis niloticus	Nile tilapia	Giant tilapia	Introduced	61.3
Barbonymus gonionotus	Silver barb	Siling	Introduced	12.7
Ellochelon vaigiensis	Squaretail mullet	Ikan	Native	5.6
Carassius carassius	Crucian carp	Imelda/Carpa	Introduced	4.4
Oxyeleotris marmorata	Marble goby	Bunug	Native	4.3
Oreochromis mossambicus	Mozambique tilapia	Native tilapia	Introduced	3.1
Netuma thalassina	Giant catfish	Kurilao	Native	2.7
Channa striata	Striped snakehead	Dalag	Introduced	2.7
Clarias batrachus	Philippine catfish	Paltat/Bangkok	Introduced	1.2
Awaous melanocephalus	Largesnout goby	Mori	Native	0.8
Clarias fuscus	Hong Kong catfish	Hito	Native	0.6
Dermogenys pusilla	Wrestling halfbeak	Balanban	Native	0.1
Zenarchopterus dispar	Feathered river-garfish	Susay	Native	0.1

Source: [1] Based on Fishbase.org. [2] Based on 20 fishing trips in 8 villages (Engelhart, 2009).

A MODEL FOR ESTABLISHING COMMUNITY-CONSERVED AREAS

Through trial-and-error, the Mabuwaya Foundation developed a model to facilitate the proclamation and management of freshwater PAs by *barangay* councils (Figure 2). A *barangay* (village) is the lowest administrative unit in the Philippines. It is governed by a *barangay* council that consists of a *barangay* captain and several *barangay kagawads* (councilors), elected by and from the inhabitants. The strength of this participatory model is that people themselves identify practical solutions for the depletion of fish stocks, based on their own values, needs and knowledge.

FIGURE 2
Participatory process to declare community-conserved areas



Source: Authors.

The participatory process starts with a meeting between staff of the Mabuwaya Foundation and the *barangay* council to discuss fisheries management (Step 1). In most villages in San Mariano, people perceive a decline in fish stocks. If a *barangay* council is responsive to address this problem, a meeting is organized with the community (Step 2). In 2005, the foundation organized community dialogues in 15 *barangays* where Philippine crocodiles occur in the wild. More than 750 people attended these dialogues and asked questions about fish and wetlands, raised concerns and proposed possible solutions (van der Ploeg, Balbas and van Weerd, 2009). These community dialogues form the start of an intensive public awareness campaign that aims to mobilize broad support for the declaration of a community-conserved area (Step 3). The foundation for example distributes posters, gives lectures in schools and organizes a dance show during the *barangay* fiesta.

The Mabuwaya Foundation then organizes a training workshop to enhance the capacity of *barangay* officials (Step 4). Most captains and councilors are unaware of environmental legislation, and do not know their rights and responsibilities. Local governance can be significantly improved by addressing this knowledge gap. During the training workshop, *barangay* officials design specific conservation action plans to conserve wetlands in their village (Step 5). *Barangay* officials subsequently present their plans to the community during a community consultation (Step 6). During these consultations people can provide feedback, voice concerns or suggest alternatives. In the end, a vote is held in which the villagers can agree with the plan, or refuse it altogether.

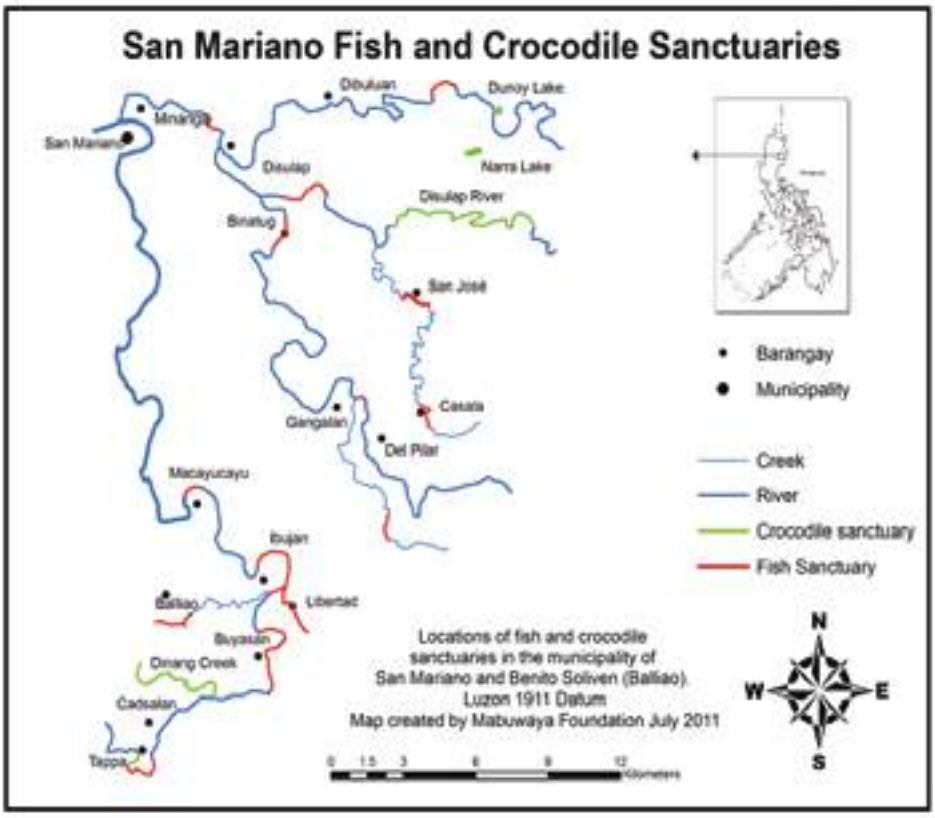
In *barangay* Cadsalan, for example, farmers initially opposed the plan of the *barangay* council to declare a 20-metre riparian buffer zone along Dinang Creek. After several revisions and lengthy negotiations, the farmers ultimately agreed to respect a 5-metre buffer zone. Such democratic processes assure that everybody in the community is aware of, and agrees with, the new rules. Moreover, these local rules are considered *legitimate* by the community, in contrast to the national laws which are generally perceived as unfair and unrealistic, and are therefore rarely enforced (van der Ploeg and van Weerd, 2004).

FIGURE 3
Barangay councilor presents the site-specific conservation action plan for barangay Cadsalan

Source: Photo courtesy of Merlijn van Weerd.

In 2005, 13 *barangays* in San Mariano passed an ordinance proclaiming a freshwater PA (Step 7). These "fish sanctuaries" as they are locally called are indicated in red in Figure 4. The rules in these community-conserved areas differ in each

FIGURE 4
A network of freshwater protected areas in San Mariano



Source: van Weerd and van der Ploeg, 2012.

FIGURE 5
Billboards are placed along the sanctuaries

Source: Photo courtesy of Marites Balbas.

area, as they depend on the specific problems and needs of the community. *Barangay* Libertad, for example, declared a part of Disalug Creek as a "sustainable fish sanctuary" where fishing is not allowed. *Barangay* Tappa only prohibited the use of "bung bong, electro fishing, cyanide fishing, fine nets and other destructive ways of fishing" in the Ilaguen River. Fishing is allowed in the fish sanctuary of *barangay* Casala, but only during the *barangay* fiesta and the *canao*, the harvest festival. *Barangay* San Jose declared a 1.5 km stretch of Ditali Creek as a freshwater PA, and specifically prohibited the cleaning of pesticides sprayers in the creek and the disposal of garbage along the riverbank.

The Local Government Code (Republic Act 7160) requires that a *barangay* ordinance can only take effect after approval by the municipal government (Step 8). The active support of the municipal government is also required for the deputation of guards that enforce the rules of the freshwater PAs (Step 9). Some *barangays* appointed a *bantay sanktuwaryo* (sanctuary guards). In other villages, the *barangay tanods* (local law enforcers) are responsible to monitor compliance. The Mabuwaya Foundation organizes paralegal training workshops where these guards practice how to give a warning, make an arrest and file a case. The municipal government pays a monthly allowance and medical insurance to the *barangay tanods* and *bantay sanktuwaryo* (Balbas, 2009).

It is then important to visually delineate the freshwater PAs on the ground (Step 10). In San Mariano, two billboards were installed in each freshwater PA. These billboards summarize the specific rules of the *barangay* ordinance and highlight the importance of the freshwater PAs in sustaining food security: each billboard prominently featured a picture of a plate full of fish. A monitoring system to report and respond to violations is obviously necessary for effective management (Step 11). Actual monitoring remains erratic, informal and unrecorded in most freshwater PAs in San Mariano (Vermeersch, 2014). In itself, that is not

FIGURE 6
Role playing game during the law enforcement training: barangay officials arrest two fishers

Source: Photo courtesy of Merlijn van Weerd.

problematic: what matters is that violators are deterred and that guards regularly update the *barangay* officials. To ensure that people in the village stay informed, the fish sanctuary is discussed in the *barangay* assembly meeting (Step 12). *Barangay* assembly meetings are held regularly to inform the community about important matters in the village. In this way the freshwater PAs are becoming part of everyday local governance.

FIGURE 7
Barangay dialogue in Disulap

Source: Photo courtesy of Merlijn van Weerd.

The last steps in the participatory model are to integrate these grassroots initiatives in supra-local legislation (Steps 13 and 14). This is important to ensure support from government and to prevent freshwater PAs from being later neglected in supra-local development plans. The freshwater PAs of six villages in San Mariano were included in the Comprehensive Land Use Plan (CLUP) and the Forest Land Use Plan (FLUP) of the municipal government. The Mabuwaya Foundation and the municipal government of San Mariano are now trying to declare these community-conserved areas as Critical Habitat Areas under the Wildlife Act (Republic Act 9147).

SUSTAINABILITY

Creating a protected area is relatively easy; sustaining its management over a long period is the real challenge. Pollnac, Crawford and Gorospe (2001), for example, report that of all community-based MPAs that are created in the Philippines, only 20 to 25 percent is maintained. Billboards are bleached by the sun or blown away during a typhoon. Fishers forget the ordinance or are tempted to harvest fish in the sanctuary. The *bantay sanktuwaryo* become weary of patrolling. *Barangay* officials are elected every three years, and the new village leaders often have different views and priorities. The policies of municipal governments are also changing rapidly. And being dependent on short-term project funding, NGOs are perhaps the most erratic management partners of all.

Ten years have passed since 13 *barangay* councils in San Mariano proclaimed a fish sanctuary. Do fishers still respect the *barangay* ordinances? Are *barangay* officials enforcing the rules and regulations? And do these community-conserved areas actually succeed to protect fish stocks and improve food security? From January to March 2014, 146 people were interviewed in ten *barangays* in San Mariano about the fish sanctuary in their village. A purposive sampling design was used, interviewing only *barangay* officials and active fishers (122 men and 24 women). People were asked if they: (1) knew the rules and regulations of the PA as specified in the *barangay* ordinance; (2) participated in decision-making processes related to the freshwater PA; (3) thought that the rules were followed; and (4) perceived an increase in fish stocks *as a result* of the sanctuary. Table 2 summarizes the main findings for each village.

TABLE 2
People's perception of the effectiveness of the freshwater protected areas

Location of the fish sanctuary	Barangay	% of respondents who are aware of the rules and regulations of the sanctuary	% of respondents who participate in decision-making processes about the sanctuary (cast a formal vote)	% of respondents who think that the rules are followed	% of respondents who perceive an increase in fish stocks as a result of the sanctuary
Amisan Creek	Del Pilar	40	40	60	100
Catalangan River	Dibuluan	52	17	32	52
Disalug Creek	Libertad	66	31	64	60
Disulap River	Disulap	87	60	53	77
Ditali Creek	San Jose	95	68	47	75
Ilaguen River	Macayucayu	17	33	–	–
Ilaguen River	Ibujan	31	29	0	92
Ilaguen River	Buyasan	89	46	15	77
Dicamay River	Tappa	0	–	10	–
Dicamay River	Dicamay	46	23	54	69

Note: n = 146
Source: Based on Vermeersch, 2014.

In some villages people's awareness of the freshwater PA is much greater than in other villages. Most respondents in San Jose (95 percent), Buyasan (89 percent) and Disulap (87 percent) are well aware of the rules and regulations of the *barangay* ordinance. In Tappa, in contrast, nobody (0 percent) knew about the *barangay* ordinance: even the *barangay* officials could not recall what the specific rules or penalties were. San Jose (68 percent) and Disulap (60 percent) also score high in terms of the percentage of respondents who feel they actively participate in decision-making processes about the freshwater PA.

Compliance with the rules is clearly a more complex issue. The specific rules and regulations differ for each *barangay*. A few simple and straightforward rules are generally easier to follow and enforce than more detailed and complex regulations. Likewise, it is much easier to implement regulations in a small and accessible area than in a large and remote area. The *barangay* ordinance of Macayucayu, for example, prohibits destructive fishing methods in the stretch of river immediately adjacent to the village. But in *barangays* such as Libertad and Del Pilar the sanctuaries are located relatively far from the village. From a biodiversity perspective, these remote creeks are arguably more important than the heavily disturbed wetlands near human settlements. However, enforcing rules in these isolated and inaccessible areas is difficult, risky and time consuming, which can discourage *barangay* officials. This tradeoff between management effectiveness and biodiversity outcomes poses a challenge for community-conserved areas.

The low numbers of respondents in Ibujan (0 percent) and Buyasan (15 percent) who think the rules are followed can be explained by the fact that commercial fishers from other villages fish in the sanctuaries at night. Local villagers generally respect the *barangay* ordinances. In fact, in 2013 the *barangay* captain of Ibujan arrested three fishers who were fishing in the fish sanctuary, and confiscated their gear. Also, in San Jose, *barangay* officials have taken action against people violating the ordinance: three men who fished with pesticides in the freshwater PA where penalized. Such cases set an important precedent, and resonate throughout the municipality. Everybody in San Mariano now knows that electro and dynamite fishing is against the law, also during Holy Week.

Perhaps most relevant is the fact that 73 percent of the respondents report that fish catches are increasing as a result of the declaration of the freshwater PAs. A fisher in Ibujan, for example, mentioned: "I can catch more fish now with my *sigay* than I could two years ago. I see the tilapia playing when I walk along the fish sanctuary." But if the benefits of creating a freshwater PA are so tangible, why do some *barangays* fail to maintain their sanctuary? Despite the fact that freshwater fish is an important source of protein for poor households, fisheries management is not a priority for most communities. This paradox can be explained by the fact that freshwater fish is regarded by most people as *substitutable*, and fishing as a *secondary* activity in a diversified livelihood strategy (Mills *et al*., 2011). People do not seem to realize the importance of wild-caught freshwater fish. As one fisher explained: "If we can catch fish, that's good, if there is none, we'll eat something else, so be it".

This clearly has important implications for community-based fisheries management: a narrow focus on increasing yields to sustain food security might not be the most effective strategy to actively engage rural communities in conservation. When asked why the *barangay* council created a freshwater PA, almost half of the respondents mentioned the need to serve fresh fish to guests during feasts or funerals. Others cited civic duty and the need to respect tradition. Such implicit, cultural values are important motivations for communities to protect fish, wetlands and wildlife; in fact, more important than explicit concerns about food security and livelihoods (van der Ploeg *et al*., 2011b: Berkes, 2013; Jupiter *et al*., 2014). The challenge is to transform these deeply entrenched cultural values into effective management of freshwater PAs.

CONCLUSION

Several communities in San Mariano have successfully maintained their freshwater PAs over the past ten years. Despite many challenges and setbacks, *barangay* officials in San Jose, Disulap, Casala, Del Pilar Ibujan and Bujasan continue to protect their fish sanctuary. People in these villages are aware of and generally respect the rules of the *barangay* ordinance, and think fish stocks are recovering as a result of the fish sanctuaries. But in other villages the community-based conservation approach has failed: in *barangays* Dibuluan, Libertad, Baliao, Tappa and Dicamay, *barangay* officials are unable or unwilling to enforce the *barangay* ordinance, and people no longer respect the fish sanctuaries. Information about the fish sanctuaries in *barangays* Minanga and Binatug is unfortunately lacking.

Three factors seem particularly important in determining the sustainability of the community-conserved areas in San Mariano: (1) the active support and leadership of the *barangay* captain; (2) the functional participation of the community in decision-making processes; and (3) continuous communication between villagers, *barangay* officials, the municipal government and the Mabuwaya Foundation. These three factors highlight the strength as well as the weakness of this community-based conservation approach. Rural communities can effectively protect aquatic resources. But in most cases, communities cannot do it alone. Outside support is necessary to initiate *and sustain* conservation action on the ground. Much can be gained if the

community-conserved areas are much more actively supported by NGOs, municipal governments, national government agencies and international donors.

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Fishers and conservation: sharing the case study of Hinase, Japan

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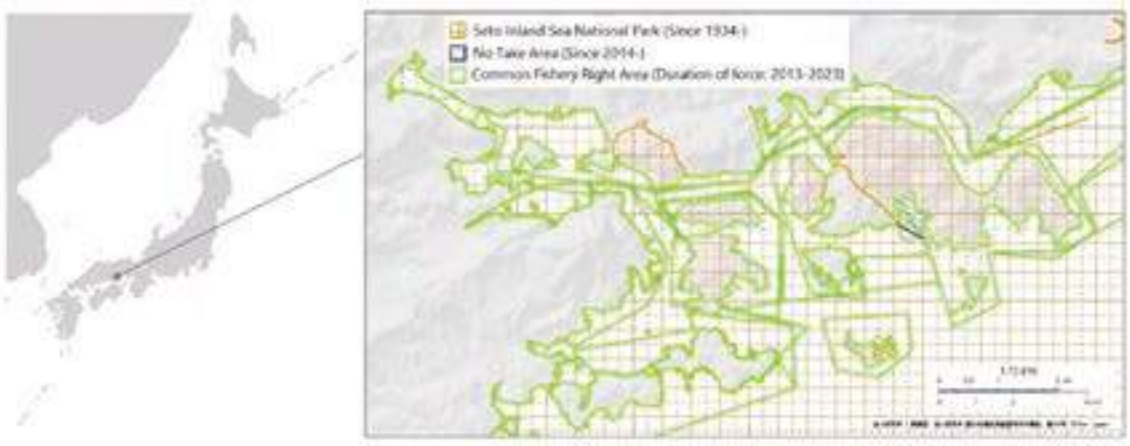
INTRODUCTION

The marine protected area (MPA) is considered by conservation institutions to be one of the most effective tools to conserve marine biodiversity and to sustain marine resources. However, only a few studies demonstrate comprehensive analysis of MPAs based on the three pillars of sustainable development and their economic, environmental and social impacts. In response, the authors initiated a three-year plan of joint research on Japanese MPAs in April 2013 to understand the effects of Japanese MPAs from a sustainable development perspective. In this paper, outcomes from two years' research at one of the case study sites (Hinase, Bizen City, Okayama Prefecture: Figure 1) is examined with particular emphasis on conservation, food security, sustainable livelihoods and fisheries by looking at the fishers' self-motivated (voluntary) initiative of eelgrass (*Zostera marina*) bed restoration. Linkages and trade-offs between conservation and resource utilization, as well as specific lessons learned for successful MPA management by the local fishers, are discussed through the sharing of their on-the-ground experiences.

FIGURE 1
Location of Hinase and the MPA relevant regulations



Source: Based on Kaiyo Daicho of Japan Coast Guard, 2015, and developed by Izumi Tsurita.

BACKGROUND

In May 2011, the basic concepts and relevant regulations of Japanese MPAs were officially announced by the 8th Meeting of the Headquarters for Ocean Policy. As announced at this meeting, the definition of the Japanese MPA is "Marine areas designated and managed by law or other effective means, in consideration of use modalities, aimed at the conservation of marine biodiversity supporting the sound structure and function of marine ecosystems and ensuring the sustainable use of marine ecosystem services" (Ministry of the Environment, 2011: 23). At the time of this announcement, there were ten MPA relevant areas under different legislation and authorities (Table 1). Current regulations and practices in Japanese MPAs "conform to various existing systems with most of them having fishery resource management objectives under either a government-based or community-based management approach" (Tsurita and Matsuda, 2013: 104). In fact, "more than 30% of the individual MPAs in Japan were established by self-imposed (voluntary) instruments agreed upon by members of fishery co-management organizations" (Yagi, *et al*., 2010: 1300) known as fishery management organizations (FMOs) and fisheries cooperative associations (FCAs) (Makino, 2013). MPAs in Japan were not primarily designated and managed as MPAs but became MPAs after 2011 (Table 1) when the government defined its concept and relevant regulations, and thus some areas could overlap as in Hinase (Figure 1).

TABLE 1
MPA relevant areas in Japan under different legislation and authorities

Area	Legislation	Authority
Natural Park	1957 Natural Parks Act	MOE or local government
Natural Coastal Protected Zone	1973 Act on Special Measures Concerning Conservation of the Environment of the Seto Inland Sea	Local government
Nature Conservation Area	1972 Nature Conservation Law	MOE
Wildlife Protection Area	2002 Wildlife Protection and Proper Hunting Act	MOE or local government
Natural Habitat Conservation Area	1992 Act for the Conservation of Endangered Species of Wild Fauna and Flora	MOE, METI or MAFF
Natural Monument	1950 Act on Protection of Cultural Properties	ACA or local government
Protected Water Surface	1951 Act on the Protection of Fishery Resources	MAFF
Coastline Marine Resource Development Area and Designated Area	1971 Marine Resources Development Promotion Act	MAFF or local government
Common Fishery Right Area	1949 Fisheries Act	FMO or local government
Area Locally or Voluntary Designated by Prefecture or Fishery Management Organizations	1948 Fisheries Cooperative Associations Act, 1949 Fisheries Act, 1951 Act on the Protection of Fishery Resources	FMO or local government

Note: MOE stands for Ministry of the Environment; METI for Ministry of Economy, Trade and Industry; MAFF for Ministry of Agriculture, Forestry and Fisheries; ACA for Agency for Cultural Affairs; and FMO for fishery management organizations.
Source: Developed by Izumi Tsurita based on NOWPAP CEARAC, 2013, and Tsurita and Matsuda, 2013.

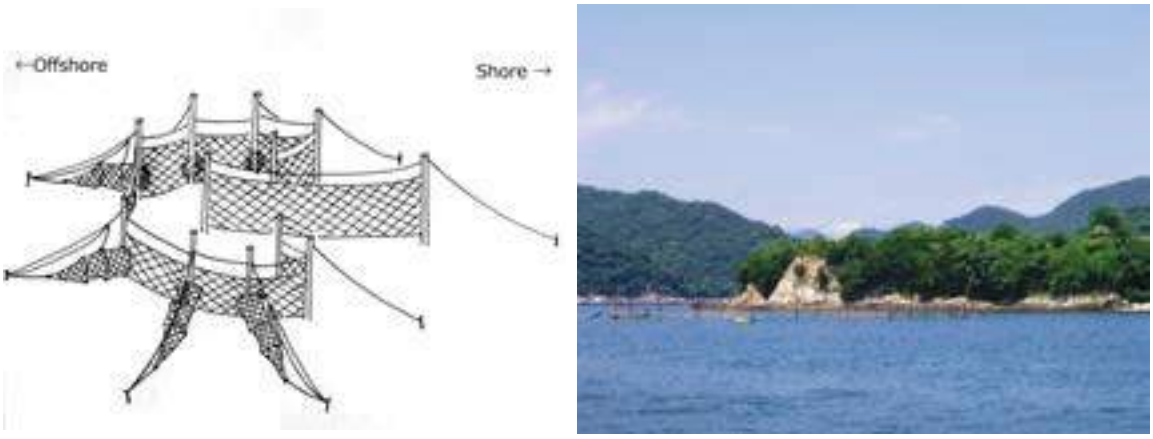
This paper highlights the eelgrass bed restoration activity conducted by the fishing community in Hinase, Bizen City, Okayama Prefecture, Japan, as an example of MPA management, because the area is covered by several MPA-related regulations according to the aforementioned discussion. The eelgrass bed restoration area is entirely covered by the Seto Inland Sea National Park (established in 1934 under the 1931 National Parks Act, which was superseded by the 1957 Natural Parks Act; Hinase was incorporated into the Park in 1950), while most of the area is also covered by the Common fishery right area (previously called as the Exclusive fishery right area under

the 1901 Fisheries Act which was superseded by the 1949 Fisheries Act) and a part is covered by the no-take area (established in 2014 by the Okayama Prefectural Fisheries Coordinating Committee, reflecting the wishes of local fishers to enhance the recovery of eelgrass beds for sustaining marine resources) (Figure 1). Generally, development activities are controlled by the 1957 Natural Parks Act, with fishing techniques, gears, and periods being discussed, shared and controlled by the Hinase Fisheries Cooperative Association (HFCA), following the rule of common fishery right area under the 1949 Fisheries Act and the 1948 Fisheries Cooperative Associations Act; all fishing techniques are prohibited under the agreement of the no-take area.

ACTIVITY

Eelgrass bed restoration was officially initiated in 1985 by fishers in Hinase, with the objective of sustaining their fish catch and supporting their surrounding marine ecosystem services (Ota and Torii, 2011). The origin of this activity goes back to the time when a staff member at the HFCA shared his scuba diving experience with members of the HFCA, pointing out the massive loss of eelgrass beds in the sea. Local fishers, especially those who practiced coastal pound netting called *tsuboami*, supported by the youth group of the HFCA, began restoring the bed after realizing that the depleted fish stocks would not recover unless the marine life habitat was improved (Tsurita, 2015). *Tsuboami* is a fishing technique that utilizes fish behavior (when a fish meets an obstacle, it turns left or right and does not go back) by setting a small net in shallow water orthogonal to the shore (Figure 2). Through routinely collecting and repairing their nets, *tsuboami* fishers gained more understanding about local conditions and came to appreciate the function and benefit of a healthy coastal ecosystem, including eelgrass beds. This local knowledge facilitated progress in their eelgrass bed restoration (Ota and Torii, 2011).

FIGURE 2
Coastal pound netting *tsuboami*



Source: Drawing by Izumi Tsurita. Photo courtesy of Izumi Tsurita.

The sea of Hinase used to have 590 ha of eelgrass beds in the 1940s, but in the 1980s, when the eelgrass bed restoration was initiated, only about 12 ha remained (Table 2), due to marine habitat destruction in the Seto Inland Sea caused by industrial and household water pollution and coastal development such as landfilling. This marine environmental problem was one of the adverse effects of rapid industrialization in Japan from around 1950 to 1970 (Ota and Torii, 2011). With local fishers' persistent efforts from 1985 to restore the eelgrass, as well as technical support from the Okayama Prefectural Fisheries

Expert Station to improve shallow water environments for cultivating and planting eelgrass, the cover of eelgrass near Hinase increased to about 200 ha by 2011 (Tanaka 2014) (Table 2), making it among the first areas to see a recovery in the Seto Inland Sea. In addition to the fishers' efforts, multiple reasons are known to have had positive impacts towards the regrowth of eelgrass beds, such as the 1973 Act on Special Measures concerning the Conservation of the Environment of the Seto Inland Sea and marine dredging controls, which gradually improved water transparency in the Seto Inland Sea. The Hinase area is now known as one of the most successful eelgrass bed restoration sites in the Seto Inland Sea (Hori, Yoshida and Hamaoka, 2011; Okazaki, 2014).

TABLE 2
Shift of eelgrass bed cover in Hinase

Year	1940s	1980s	2011
Cover	590 ha	12 ha	200 ha

Source: Developed by Izumi Tsurita based on Tanaka, 2014.

FIGURE 3
Eelgrass meadow in Hinase (left) and stakeholders collecting eelgrass to mature the seeds (right)

Source: Photos courtesy of Izumi Tsurita.

Considering such changes in the sea area of Hinase, this joint research focused on studying the ecological, economic and social outcomes of this eelgrass bed restoration (Table 3). As for the ecological outcome, according to the field data, it became clear that the ecosystem of recovering eelgrass beds is now nearing its wild condition, with increased benthic primary production (Figure 3: left). Hence, the functions of the benthic biophysical cycle, including supporting spawning and growing grounds for specific marine organisms, are increasing, which is resulting in a catch increase (e.g. *Siganus fuscescens*, *Sphyraena pinguis* and *Penaeus semisulcatus*).

As for the economic outcome, an increase in fishers' incomes has been difficult to determine due to various changes in the market, such as the price of fish and consumer demand. The price and demand for fish have shifted dramatically since the initiation of the eelgrass bed restoration as a result of multiple factors, including trade globalization. Identifying the factors responsible for an increase in fishers' incomes is becoming even more challenging because many of the fishers are now shifting from the use of coastal fishing techniques to oyster farming due to its stable benefits and labour costs. These issues will be further discussed in the following section.

As for the social outcome, through various interviews it became clear that the eelgrass bed restoration activity is expanding the social network. During the initial

period, *tsuboami* fishers were the main actors who voluntarily collected and seeded eelgrass, while now the activity is being conducted by the entire membership of the HFCA. To date, the activity is also inspiring other groups such as NGOs, junior high school students and members of the Consumers' Cooperative Society (Figure 3: right).

TABLE 3
Outcomes of the eelgrass bed restoration

Ecological	Increasing function of biophysical cycle (increasing productivity)
Economic	Income increase unidentified due to multiple external factors
Social	Expansion of social network

Source: Authors.

DISCUSSION

Fishers, as the main actors in the eelgrass bed restoration in Hinase, have chosen long-term strategies to recover their fish catch and to support their surrounding marine ecosystem services by improving fish habitat. In other words, their eelgrass bed restoration activities integrated objectives of both conservation and resource utilization. Even though the newly established official no-take area (2014) may result in short-term trade-offs between eelgrass bed restoration and resource utilization for some of the fishers' groups who practiced fishing in the area, sustainability of their marine resources is expected to be ensured in the long term, considering the spillover effect. Habitats for marine species, such as spawning, nursery and feeding grounds, which are the basis for ensuring marine food security and fishers' livelihoods, are improving with the increase of eelgrass beds.

Notable points about the eelgrass bed restoration in Hinase were its spontaneous development by the *tsuboami* fishers and the fact that technical support by Okayama Prefecture was available when needed. For decades, change in eelgrass bed cover was not visible, and at times the recovered areas were washed out by wave disturbances. However, fishers patiently continued their work and gradually expanded the eelgrass cover, which in turn expanded the social network. Depending on the fishers' needs, the municipal, prefectural, and national government agencies provided technical and financial supports such as research data, habitat restoration investments and per diem allocations for the eelgrass restoration. As the recovery of eelgrass beds became visible, the social network expanded to other fishers' groups in HFCA, government agencies, NGOs and the local community (Tanaka, 2014).

The exact contribution of the restoring of eelgrass beds to an increase in fishers' income is not yet clear due to multiple factors, including the globalized market. The local price of fish is now affected by an increase in imported fish, aquaculture products and other protein sources such as beef. In addition, with changing social practices, the preference of consumers is shifting from whole fish to fillets to reduce household cooking burdens. In response to such changes, a number of fishers in Hinase are switching to or additionally operating oyster farming to maintain income. Currently, local thinking is that the increase in eelgrass beds may contribute to reducing the sudden death of oysters and to promoting their growth. However, there are also concerns that continuous oyster farming may not be sustainable over the long term, considering future marine environmental change, especially high sea water temperature, due to climate change. Moreover, considering the input and output of the oyster's life cycle that impacts surrounding environment, large-volume oyster production may reduce the resilience of local marine environments, as well as sustainable livelihoods if production and demand are negatively affected by unexpected ecological and social impacts. Maintenance and improvement of marine habitat through eelgrass bed restoration could function to maintain food diversity and, thus, to secure another food supply if a decline in oyster farming occurs. Hence, eelgrass bed restoration is likely to

contribute to supporting food security and sustainable livelihoods even as an economic safety net.

In addition to eelgrass bed restoration, a comprehensive management system is recommended to further secure fishers' livelihoods. The 1973 Act on Special Measures concerning the Conservation of the Environment of the Seto Inland Sea and dredging controls by the prefectural and national government certainly contributed to improving the water transparency of the Seto Inland Sea and to recovering eelgrass, but reduced the flow of nutrients and organic material, thus hindering the production of some marine resources such as seaweeds (*Pyropia* sp). It is also known that the act did not effectively control coastal landfilling activities, which resulted in the destruction of coastal habitats such as seagrass and seaweed beds as well as mudflats (Matsuda, 2014). Therefore, it is hoped that revising the current hydraulic engineering system will further restore the marine biophysical cycle. In addition, application of policies for the preservation of the local foods and fishing culture and for the regulation of aquaculture and other fishing techniques in response to changes in the marine and social environment would be advantageous in securing local livelihoods. Appropriate policies could function as a safety net. The revised Basic Plan on Seto Inland Sea endorsed by the Cabinet in February 2015 and the 1973 Act on Special Measures concerning the Conservation of the Environment of the Seto Inland Sea amended in September 2015 comprehensively shifted their objective from a "clean sea" to a "rich sea" by stressing community participation and horizontal regional partnership, but their tangible outcome depends on integrated financial support from the central government in addition to local and regional efforts (Matsuda, 2015).

CONCLUSION

Self-motivated (voluntary) management practices initiated by the fishers in Hinase provide lessons not only for maintaining food security and livelihoods but also for recovering the marine environment. Thus, along with support from government agencies, local understanding of the environment can be enhanced if people are sufficiently motivated to improve their degraded marine resources. When analyzing the cause and effect of their activities in the long term, complex multiple impact factors have to be recognized, such as shifts in the economy and society surrounding the fishery industry. Research revealed that there is a need for cautious steps to identify adequate indicators to establish a good economic monitoring system if the trends in economic well-being and the contributions of various factors to well-being are to be determined. These lessons can be of use to both developing and developed countries facing similar environmental issues caused by rapid industrialization and urbanization. The recovery of eelgrass beds is enhancing fishers' direct well-being (e.g. social network) as well as indirect well-being (e.g. resilience of local marine ecosystems to ensure their food security and sustainable livelihoods). Currently, not only the fishers but also high school students and NGOs, as well as government agencies, are motivated to conduct similar activities in Japan, with the aim of restoring coastal habitat through eelgrass restoration. Nonetheless, it is important to note that the success of Hinase did not come about without the long-term committed efforts of local fishers and adequate support from other stakeholders at the right time.

ACKNOWLEDGEMENTS

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Changes in fisheries production following large scale expansion of no-take closures within the Great Barrier Reef, Australia: the results, the debate and implications for policies related to food security

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INTRODUCTION

Despite the many predictions of fishery benefits being generated from no-take closures (e.g. Gell and Roberts, 2003), there have been few empirical studies that report on the actual changes in catches generated following the implementation of closures (e.g. Hilborn *et al*., 2004; Penn and Fletcher, 2010). Studies of the effects of closures generally examine the relative densities of selected fish species within and outside of closures, from which the broader benefits to surrounding fisheries are mostly only inferred (Sale *et al*., 2005).

One of the few studies that has undertaken an empirical assessment of the regionwide effects on the catch levels of fisheries directly affected by large-scale increases in no-take closures was an examination by Fletcher *et al*. (2015) of commercial catches in the Great Barrier Reef Marine Park (GBR). This study examined the effect on the catch levels following an increase in the area of the 348 000 km^2 GBR, closed to all forms of fishing, from 4.6 percent to 33 percent in July 2004 (GBRMPA, 2005). The advice that had been provided to government in support of these closures stated that they would only generate relatively small (10 percent) and short-term (recovery to begin in three years) reductions in commercial catch within the GBR (BRS, 2003; GBRMPA, 2003).

FIGURE 1
Examples of the types of prawn/scallop trawlers that operate within the GBR

Source: Anom.

The Fletcher *et al.* (2015) study examined the accuracy of these predictions, and by inference, their underlying assumptions, by comparing the pre- and post-closure commercial catch data both within and outside of the GBR using a beyond-BACI design. Since the publication of this study, the main debate has been about the analytical methodology applied (Hughes *et al.*, 2016; Fletcher *et al.*, 2016). There has not been any consideration of the implications these results may have for the potential costs and benefits of fishing closures, especially for the delivery of policy outcomes including food security. Here the outcomes from the GBR study are outlined along with a summary of the criticisms raised and their rebuttal.

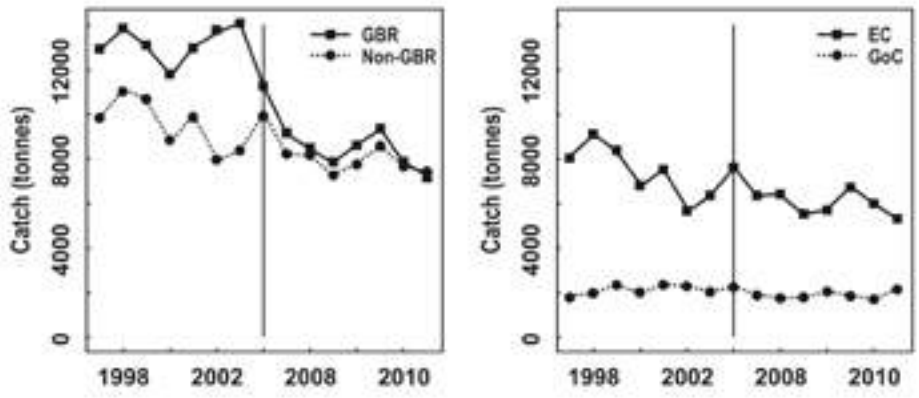
GBR STUDY RESULTS

Fletcher *et al.*, (2015) analysed the effect of the additional on fisheries by comparing the commercial catch levels for periods before and after the closures within the GBR and also for two other Queensland reference regions, with the following a summary of their findings. They found that following implementation of the rezoning in the GBR in July 2004, the average total catch of commercial fisheries within the GBR (all of which are managed by Queensland Fisheries) immediately declined by greater than 30 percent, and importantly, there had been no recovery in these catch levels after nine years (Figure 2a). By contrast, such declines were not observed for the same or other Queensland-managed fisheries operating in the two non-GBR reference areas (Figure 2b).

FIGURE 2

a) Total annual commercial catch (t) in the GBR area and the combined non-GBR area

b) Total annual commercial catch levels (t) in the two non-GBR regions, East Coast (EC) and Gulf of Carpentaria (GoC)



Note: The vertical lines indicate the time (July 2004) when the increases in area of the no-take closures occurred.
Source: Fletcher *et al.*, 2015.

In addition to the decline in total catch levels, there were significant post-rezoning declines in the commercial catches across most taxa (crustaceans, finfish and molluscs; 20–40 percent declines) and fishing operations (trawl and line fishing; 30–60 percent declines) within the GBR (Table 1). Importantly, Taylor, Webley and McInnes (2012) found that the catch levels of key fish species by the recreational sector, which were subject to the same rezoning closures within the GBR, also declined by 50 percent, which was similar to the decline observed for the commercial line fisheries. The magnitude of these declines suggests that important line fishing habitats may have been overrepresented in the closures which warrants more detailed investigations.

TABLE 1
Average commercial annual catch levels (t) for the fishing methods used and main taxa caught in both the GBR and the Non-GBR pre- and post-expansion of the closed areas

Taxa/fishing method	GBR			Non-GBR			Impact of rezoning
	Pre	Post	% Change	Pre	Post	% Change	BACIP*
Finfish	5 935	3 170	–46	5 840	5 670	–3	P < 0.001
Crustaceans	5 265	3 660	–30	2 526	2 933	16	P < 0.001
Molluscs	503	380	–25	254	246	–3	P < 0.05
Sharks and rays	996	505	–49	690	594	–15	ns
Line fishing	4 950	2 003	–60	671	769	14	P < 0.01
Net fishing	1 978	1 670	–15	5 857	5 534	–5	ns
Trawling	5 824	4 067	–30	2 989	3 262	9	P < 0.01

*BACIP is the Paired Before, After, Control, Impact two sample t-tests.
Source: Fletcher *et al*., 2015.

The reductions in catch levels observed in the GBR were well in excess of the predicted 10 percent and much greater than could be directly attributed to any non-zoning management interventions (e.g. effort buy-backs and quotas) or natural events (e.g. cyclones) at that time. This indicated that a decade after the closures were implemented, "there was still no evidence of longer-term net fishery benefits being reflected in any material recovery in catches". Similarly, the persistence of the declines in total and category-level commercial catches observed within the GBR were "not consistent with either detectable, widespread increase in recruits entering the fishery or a 'spillover' of adults". Fletcher *et al.* (2015) concluded that these results did not support the predictions presented to government which were based upon the expectation that large-scale closures to all types of fishing will "benefit or at worst have neutral impacts on (surrounding) fisheries" (GBRMPA, 2003). Instead, they supported an alternative hypothesis (Fletcher, 2003; Hilborn *et al*., 2004; Walters, Hilborn and Parrish, 2007; Penn and Fletcher, 2010; Kearney, Buxton and Farebrother, 2012; Buxton *et al*., 2014) that where fish stocks are already effectively managed, "generalised no-take closures are likely to result in reductions in overall catch".

FIGURE 3
Some of the key finfish species (including coral trout and red throat emperor) captured by commercial and recreational line fishing within the GBR

Source: Anom.

EXAMINATION OF THE CRITICISMS

With the significant discrepancies between the predictions and outcomes found for changes in the commercial catch levels within the GBR following the expansion of the fishing closures, a strong reaction following the publication of these results was not surprising. At this stage, however, the reactions have been restricted to criticisms of the analytical approach applied.

Hughes *et al.* (2016) have stated that the study used a "flawed BACI design with inappropriate controls, overlooked or omitted fisheries data, failure to recognize that new no-fishing zones were placed to minimize impacts on existing fishing practices, and [used] the incorrect supposition that other substantial fisheries changes that were specifically designed by fisheries managers to reduce or cap catches are trivial".

FIGURE 4
A typical commercial net fishing operation within the GBR

Source: Anom.

These four criticisms were responded to in detail by Fletcher *et al*. (2016) who argued (1) the suitability of using the beyond BACI design where there can be no true controls plus the appropriateness of the combined non-GBR data for comparison with the GBR data was supported by further statistical analyses which found there were strong correlations between the de-trended residuals for both total catch and total catch-rates for these two data sets, (2) the strong justification that as the fisheries within the GBR are all managed by Queensland Fisheries, it was most appropriate to compare the catches by the fishing operations within the GBR with similarly managed fisheries that operate in non-GBR areas; (3) the actual catch data used are independent of the reasons used to select the areas that were ultimately closed; and (4) the potential direct impacts of each of the major non-zoning management interventions affecting Queensland-managed fisheries were already specifically examined and accounted for in the analyses. From this it was concluded that the critique by Hughes *et al*. (2016) did not provide "empirical data or quantitative assessments that effectively challenge or invalidate our analyses or the legitimacy of what we consider are moderate conclusions" (Fletcher *et al*., 2016). Given the passion that is regularly associated with discussions about the benefits or impacts of no-take fishing closures, it is unlikely that this will be the end of this debate.

DISCUSSION

The debate outlined above highlights the difficulties often encountered when attempting to examine the impacts of management changes that extend over large spatial areas and time scales, especially where the changes purport to simultaneously deliver multiple (and essentially competing) policy outcomes. In such circumstances, it is not possible to have true controls that can replicate thousands of kilometres of coastline and management systems. This, however, is the scale over which the stocks of most harvested fish species are distributed and, therefore, the scale at which fishery-level impacts need to be measured, i.e. they cannot be measured at the scale of each closure. Consequently, to undertake any type of empirical examination of the effects of management changes at this scale, one must recognize the inevitable analytical limitations in the experimental designs that will be possible and, therefore, the reduced specificity in the conclusions.

The vigour used in these debates may reflect the strong advocacy that accompanies the promotion of this type of spatial management strategy. Rather than being seen as a tool, closures are often now promoted as the "process-based" management objective such as through the setting of international closure targets (IUCN, 2014) rather than by establishing outcome-based targets that are more appropriately related to actual stock status or biodiversity levels. This suggests that the instrument is being confused with its anticipated results (Kearney and Farebrother, 2014).

The frequent ambiguity in the use of the various terms associated with "marine protected areas" can also impact on objective decision-making processes that are needed to deliver the best overall community outcomes related to food security.

A good example is the title of Hughes *et al.*'s critique of the GBR which was "… claims for negative impacts of Marine Protected Areas on fisheries". As pointed out by Fletcher *et al.* (2016), this misrepresented both the purpose and outcomes of the Fletcher *et al.* (2015) study which was very specifically focussed on examining only the impacts of no-take closures on fishery production.

The fishing closures used in the GBR are just one of a wide spectrum of spatially-based management tools that can collectively be termed marine protected areas (MPAs) are currently in use across most jurisdictions in the world to assist with the management of fisheries and other conservation-related objectives. The broader issues associated with the relative value of all types of MPA on fisheries (as discussed, for example, in Garcia, Boncoeur and Gascuel (2013) were neither studied nor even discussed in Fletcher *et al.* (2015). Similarly, despite the clear reductions in catches in the GBR following rezoning, this study did not make "criticisms of MPAs". First, as the rationale for the rezoning of the GBR was not solely focused on fishing but covered a range of objectives, these would each need to be examined to ascertain the "success" or not of this scheme. Even in relation to fisheries, Fletcher *et al.* (2015) specifically cautioned against the use of generalized assumptions about "what must happen" in relation to closures and stated that "proposals for closing areas to fishing should be preceded by critical evaluation of the likely outcomes and realistic estimation of costs and benefits based on the specific circumstances in each jurisdiction and location".

Because large multiuse MPAs are complex social-ecological systems, the expectation that if a particular result is observed in one location the same outcome should be expected in all other circumstances and locations is not only naïve but dangerous. This is especially the case for those trying to determine the best management option to deliver suitable community outcomes. It is, therefore, both timely and heartening that FAO has discussed the need for a study to compile the available empirical and other forms of information related to MPAs and fisheries and food security from around the world in order to develop a decision-support tool (Miller, Sanders and Westlund, 2016). Such a tool could be designed to help policy-makers understand what outcomes each type of MPA can be expected to generate given the prevailing or expected environmental and governance conditions that operate within their region or jurisdiction. Depending upon the objectives being sought, and the specific local conditions, implementing no-take closures may either be a suitable or an unsuitable option.

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Alternative solutions for a traditional society undergoing change: support for adding value to Imraguen fishery products from Banc d'Arguin National Park, Mauritania

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INTRODUCTION

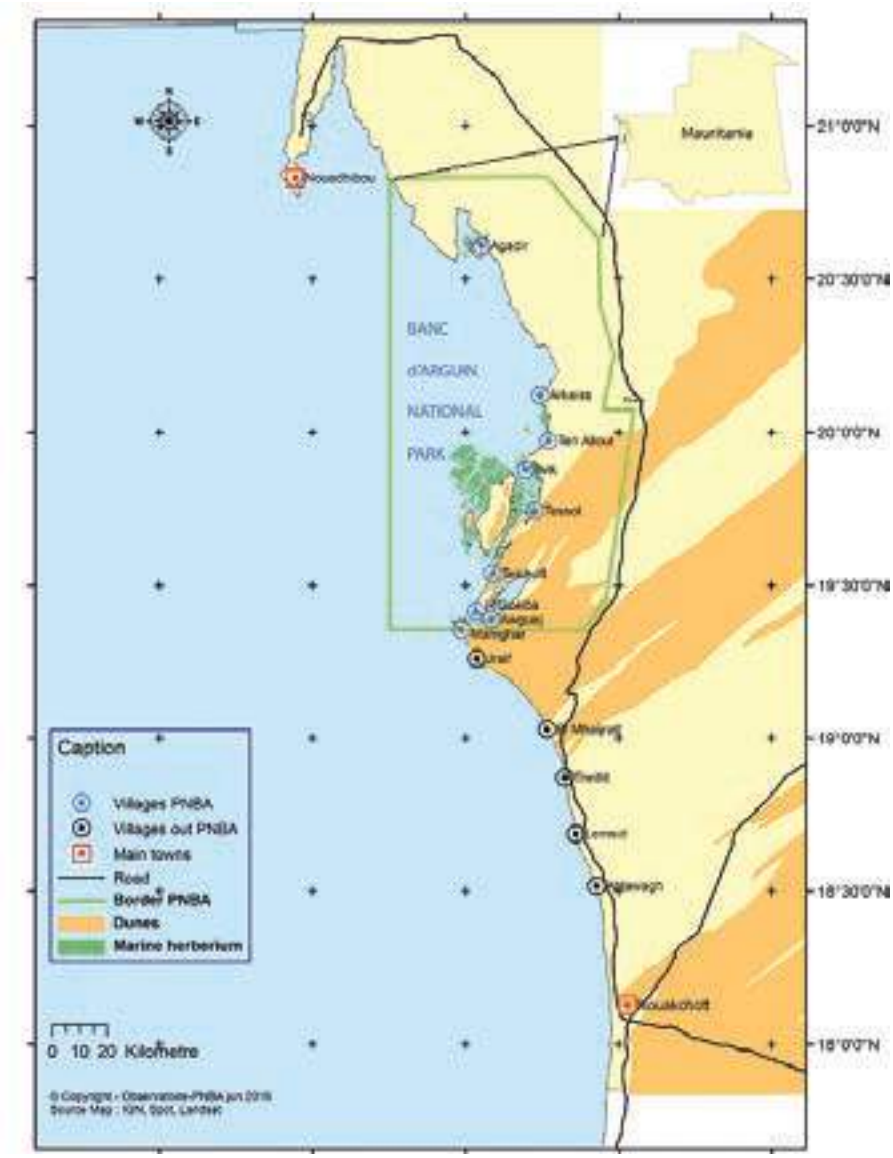
In 2016, Banc d'Arguin National Park (PNBA) will celebrate 40 years from its founding. Extending over an area of 12 000 km, PNBA, which is almost half marine and half terrestrial, is Africa's second largest marine protected area (MPA). Listed as a UNESCO World Heritage Site in 1989, PNBA has undergone over four decades a spectacular increase in fishing pressure from local fishers. The number of fishing vessels rose from 50 units in 1965 to 114 units in 2006, and total annual catches doubled from 1 500 tonnes to 3 500 tonnes between 2000 and 2010. The Imraguens[1] populate nine villages in PNBA and are the only people allowed to live in this MPA. They have exclusive access rights to the fishery resources provided they use traditional subsistence fishing methods on boats fitted with lateen sails known as *lanches*.

The PNBA was established in 1976 to preserve biodiversity, particularly migratory bird colonies. In 2000, the objectives broadened[2] to include development of the local communities, which was deemed to be an integral part of the ecosystem, and the park's management adopted a development and management plan (DMP).

The aim of this paper is to examine the measures taken by PNBA management and the donors of the PNBA to reduce fishing pressure on Banc d'Arguin's resources. It will discuss the community support projects and consider the effects they have had on the communities, the local economy and food security.

[1] Imraguen means a man who goes into the water and fishes with a "shoulder net" (Boulay, 2013: 219).
[2] Section 2 of the Banc d'Arguin National Park Act No. 2004/024 lists, inter alia, the purpose of "facilitating the harmonious development of the residents who use the Park's natural resources".

FIGURE 1
Map of Banc d'Arguin National Park



Source: Observatoire-PNBA, 2015.

FISHING PRESSURE AND PARK RESOURCE MANAGEMENT STRATEGY

From supposedly "subsistence" fishing to commercial fishing

Traditional Imraguen fishing is based on the ancestral shore fishing method, using a "shoulder net" to catch flathead grey mullet (*Mugil cephalus*). Contrary to popular belief, the Imraguens not only fished for subsistence, but were involved in a full-fledged fish trade. Their dried fish was highly valued by Moorish caravan drivers who travelled through the Western Sahara (Picon, 2002: 16). Flathead grey mullet bottarga[3] was also a highly prized product produced by the French company Société Industrielle de la Grande Pêche (SIGP)[4], which turned it into a lucrative trade, buying directly from Imraguen fishers in Banc d'Arguin from 1930 to 1973.

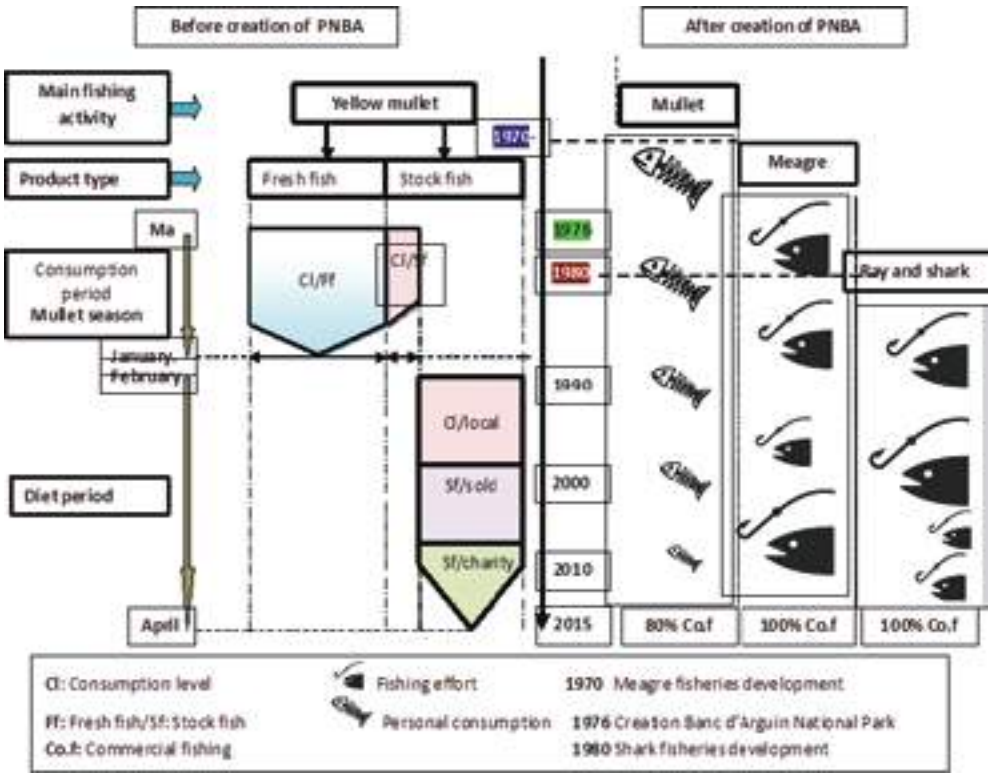
[3] Salted, dried product made from flathead grey mullet roe.
[4] Société Industrielle de la Grande Pêche (SIGP) was established in 1919.

Canary Island fishers introduced sailboats into the Banc d'Arguin in the seventeenth century (Picon, 2002: 7). In the 1930s, a few Imraguen fishers learned carpentry from craftsmen migrated from the Canary Islands and began repairing, building and by 1937 owning *lanches*.

In response to a fast-growing demand by the Spanish for fish in the 1940s, 1950s and 1960s, (Boulay, 2013: 55), fisheries of meagre (*Argyrosomus regius*) expanded throughout the Banc d'Arguin area. In 1960, Canary Island fishers landed no less than 7 000 tonnes of meagre at Port Etienne[5] (Picon, 2002: 59). The Imraguens began fishing for meagre in earnest in the 1970s. Due to a succession of events, they were able to maintain a literal monopoly over meagre in the Banc d'Arguin. These events included Mauritania's independence in 1960, the decolonization of Spanish Sahara in 1976, the closure of the main Spanish fishing company, INI-IMAPEC in Nouadhibou[6] in 1980, and the ensuing, virtually-permanent departure of Canary Island fishers.

Before leaving Mauritania, the Canary Islanders sold their *lanches* to the Imraguens, who very soon increased the number of boats to further explore the Banc of Arguin inland waters for flathead grey mullet and to trade in the main species found there, namely, meagre, which after being dried was sold in Nouadhibou, and selachians (rays and sharks), for which PNBA is considered a sanctuary with more than 40 species (DMP, 2009). Driven by attractive prices for shark fins on the world market, this fishery developed considerably from the mid-1980s, helping "to change fishers' mindsets to think in terms of personal gain" (Boulay, 2013: 79). The effects were irreversible: traditional fishing seasons and grounds were disregarded, and shore fishing was almost completely abandoned. The gap between rich and poor Imraguen households widened.

FIGURE 2
The historical development of Imraguen fisheries in Banc d'Arguin waters



Source: Author, 2015.

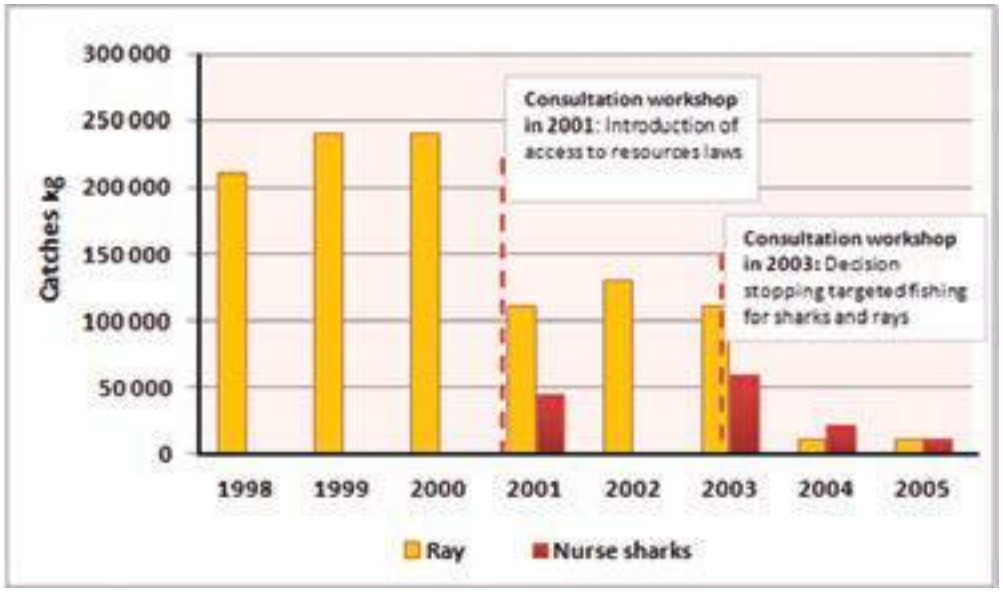
[5] Port Etienne is now named Nouadhibou.

[6] Nouadhibou is a coastal town located to the northwest of the Banc d'Arguin on Cape Blanc Peninsula.

Fisheries resource management strategies

In order to reduce fishing pressure, the PNBA authority resorted to legal measures and sought financial assistance from the Fondation Internationale du Banc d'Arguin (FIBA). Since 2000, fishing has been prohibited for all vessels except sailing *lanches*, the number of which has been capped at 114 units since 2006. In response to the concern over fisheries that targeted selachians, many researchers recommended that the park authorities ban them. Following two workshops with PNBA managers, the Imraguen fishers committed in 2003 to stop using selachian nets and targeting the species. A total of 98 km of ray nets and 7 km of shark nets were destroyed. Figure 3 illustrates the impact of these measures on selachian catches.

FIGURE 3
Selachian catches in PNBA from 1998 to 2005



Source: Araujo 2007.

To offset the revenue shortfall to fishers after the selachian ban, PNBA and its partner FIBA decided to revive[7] meagre fishing as an alternative to fishing for selachians, and offered the fishers attractive incentives.

The ARPI programme (Programme d'Appui à la Reconversion de la Pêche Imraguen: Imraguen Fisheries Conversion Support Programme) offers village cooperatives support in the form of microloans to buy *lanches*, vehicles for hauling gear, ice and cold-storage equipment for fish produce. According to the figures of the Mauritanian Institute for Oceanography and Fisheries Research (IMROP) on Imraguen fisheries monitored within PNBA, average annual production for 89 active *lanches* more than doubled during the period 1999 to 2010 from 1 500 tonnes to 3 500 tonnes per *lanche* (IMROP, 2010). Average annual income per *lanche* for the period was estimated at €3 370 (Tarbiya, 2012).

Based on fishery yields, it could cautiously be inferred that the support offered to fishers boosted the local economy. Because reliable monitoring data were not available prior to the ARPI project, i.e. before 1999, an objective, quantified comparison between pre-project and post-project fisheries income cannot be made. Also, although the post-project outcomes appear at first sight to show that the conversion to a meagre fishery was a success, they quite unexpectedly proved to conflict with the fisheries management objectives.

[7] Meagre was fished by the Imraguens from the 1970s to the 1980s, but was promptly abandoned because targeting selachian species is economically much more interesting.

Conversion glitches

Conversion, as seen by FIBA and PNBA, was about reducing fishing pressure on selachians, while at the same time offsetting fishers' losses from the selachians ban with microloans that in the medium-to-long term would not jeopardize the park's conservation objectives. Wishing to continue reconciling resource conservation with community development, the park's management persuaded the park fishers to return to using meagre nets to replace the selachian nets destroyed a year earlier. The meagre nets proved highly effective in catching meagre, as Taleb Sidi (2007) reported that 98 percent of landed meagre was caught with these nets. Against all expectations, however, the park management noted that the nets were not selective in terms of bycatch, as they accounted for 80 percent of ray catches and 40 percent of shark catches (Cheikh Baye, 2012). It would appear that the meagre net mesh size was fraudulently altered by stretching it to 340 mm from the regulation 240 mm. Imraguen fishers had found an ingenious way of illegally catching selachians, while ostensibly using perfectly legal meagre nets.

Following this twist of events for selachians, the park management decided to implement two combined measures: 1) further tighten checks on landed catch and severely penalize offenders; and 2) maintain the regulation "meagre net" while allowing a quota of selachian bycatch. Despite these measures, however, so-called selachian "bycatches" remained large. The percentage of landed selachians hovered around 8 percent of total annual landings from 2000 to 2006, rising to 30 percent in 2007, and even exceeding 50 percent of total annual catches in 2008, 2010 and 2011 (Ebaye, Ould Sidi Cheikh and Ould Yarba, 2013). In 2012 alone, total landed cartilaginous fish (rays and sharks) exceeded bony fish (meagre, mullet, tilapia, demersal and pelagic species, and catfish): 1 752 tonnes of cartilaginous fish compared with 1 459 tonnes of bony fish.

Repercussions on Imraguen women's means of livelihood

The direct effects on the economy of the activities of the Imraguen women, which are closely tied to fish processing, are discussed in this section. Fish processing is the only source of "visible" income for women in the park. The opportunity cost of the selachian fishing boom from 1980 to 2003 and the arrival of ice in the park[8] was that the fishery economy shifted from cottage-industry processing of the catch to the marketing of fish on urban and foreign markets, resulting in the closing down of the processing of flathead grey mullet in most Imraguen villages and the banishing of the Timragâten[9] women fish processors from the fishery economy (Boulay, 2013). The time when women were entitled to a free share of the catch was over. Currently, fresh fish has to be purchased for processing, sometimes at steep prices.[10] Occasionally, fish caught by the local fishers does not appear on the market, because it has been presold to powerful customers (the park wholesalers) who snap up the whole yield in one fell swoop for urban markets. As a result, women have significantly less business, which in turn affects household food security and diet.

Two social and economic surveys taken in 2003 on home consumption of fish products by the Imraguens are currently available. The first survey only examines the consumption of processed traditional products, such as mullet bottarga and dried, salted fish, etc. The second survey was conducted as part of the Towards Sustainable Imraguen Fisheries (VPDI) project and looked at home consumption of fresh produce. This survey found that out of a total annual landing of 2 171 710 kg of fish in 2003, only 2 158 kg of fresh fish were locally consumed, i.e. a consumption ratio of approximately

[8] Ice contributed to increasing the fishing effort in the park. Fish wholesalers have since been able to store their catch for several days before shipping it to urban markets.

[9] Timragâten refers to an Imraguen woman "who knows how to slice fish" (Boulay, 2013: 219).

[10] Early in the season, a mullet piece sold for MRO 100 to MRO 150. The price gradually rose to MRO 300 from the middle to the end of the season, i.e. doubling or tripling in price.

0.1 percent. These figures need to be treated with a great deal of caution, however, as the Imraguens are totally dependent on the park's fish resources. According to FAO statistics[11] on world fish consumption by continent, Mauritania had a per capita consumption index of 9.6 kg in 2010. If applied to PNBA's population of 1 500 people, this average consumption figure would come to approximately 15 tonnes, which, for a 3 500-tonne total production by all lanches, would be considered very small.

The women use their income from processing to cover the family's two main expenditure items, i.e. 68 percent for food and 20 percent for water (CERTIF, 2009: 29). In addition to declining income due to dwindling trade for the women, fish for home consumption has become scarce as well. The decline in income has led to poverty in many Imraguen households, owing to indebtedness, which in turn has impoverished their eating habits. The Imraguens' main source of animal protein, namely fish, is being replaced by protein from tinned sardines and tuna that some households eat with rice.

TOWARDS REVIVING FLATHEAD GREY MULLET PROCESSING

Donor support strategies

To preserve Imraguen women's knowhow and restore them to their important status in a traditional society in constant economic flux, FIBA, IUCN and PNBA jointly implemented a portfolio of projects since 2000 aimed mainly at "supporting female producer groups in order to promote local processing of fish products". They consisted of four phases focussing on access to catch, improving production conditions, packing and product marketing.

In order to facilitate access to catch that is usually bought up by fish wholesalers, zero-interest microloans were granted to groups of women processors for the purpose of improving production conditions through various initiatives, namely: building modern processing sheds (locally known as *tikit*) in five villages;[12] strengthening women's capacity in hygiene and processing management; testing added value due to bottarga quality enhancement and measuring its local marketing potential; and providing processing equipment and new packaging for the finished product.

Successful recovery outcomes

The various projects (ARPI, VPDI, RARES)[13] from 2000 to 2007 yielded encouraging results in terms of preserving Imraguen fish processing techniques.

The financial outcomes of the 2006–2007 test on packaged bottarga were as follows:

- The bottarga usually sold to park wholesalers for MRO 1 200 to MRO 2 500 per kg and sold in the park for MRO 4 000 to MRO 6 000 per kg, depending on the quality, instead was sold to private individuals or restaurants in Nouakchott for MRO 12 000 per kg.[14] Improved preservation and processing of bottarga in Nouakchott resulted in 50 to 60 percent greater proceeds.
- During the 2006–2007 season, the 76 kg of bottarga produced by the women's groups, which took part in the test phase, made a turnover of MRO 1 137 321, excluding the turnover from mullet by-products, such as oil, lekhlee and tishtar (Table 1).

[11] World apparent consumption by continent available at: ftp://ftp.fao.org/FI/STAT/summary/default.htm
[12] Agadir, Mamghar, R'Gueiba, Teichott and Tessot villages.
[13] ARPI: 2000–2001. VPDI: Towards Sustainable Imraguen Fisheries (Vers une Pêche Durable Imraguen), 2002–2004. RARES: Natural Resource Access Regulation and Monitoring in PNBA (Régulation de l'Accès aux Ressources Naturelles et Surveillance au PNBA), 2005–2007.
[14] €32 per kg.

TABLE 1
Income earned by Imraguen women from fish products in the PNBA area, 2006–2007

Product	Bottarga	*Lekhlee*	Oil	*Tishtar*	Total turnover
Total income (in MRO)	**1 137 321 = €2843** (Exchange rate: €1 = 400 MRO)	**257 930 = €645** *Lekhlee* is dried, pounded fish flesh	**48 500 = €121**	**30 960 = €77** *Tishtar* is dried, shredded fish	**1 474 711 = €3686**

Source: Le Douguet and Bernardon, 2007.

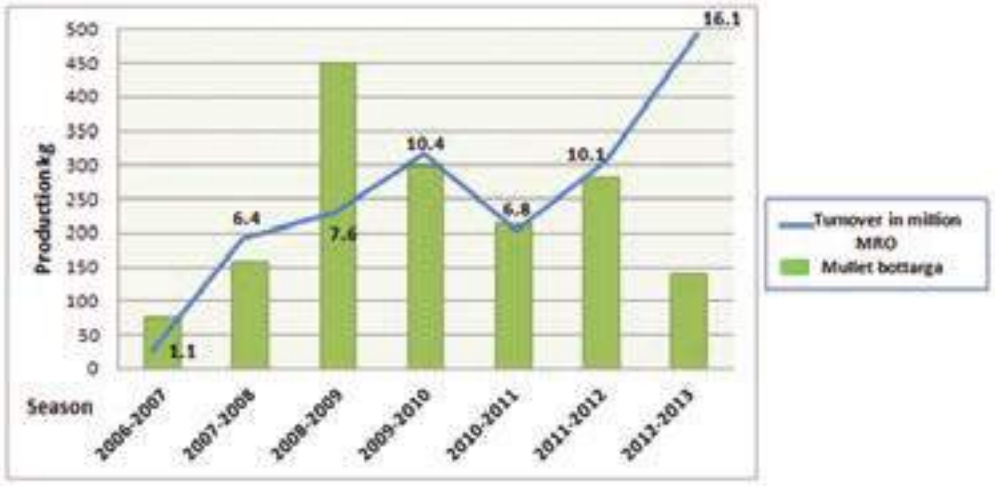
FIGURE 4
A: Loans being paid out to women's groups from the cooperative's working capital. B: Traditional tikrit in the Mamghar municipal area. C: Modern or upgraded tikit in R'Gueiba village. D: Egg extraction. E: Mullet bottarga. F: Packaged bottarga.

Source: Photos A, B and C courtesy of the author, 2014; photo D courtesy of Matthieu Bernardon, 2007; photos E and F courtesy of Louis Le Douguet, 2007.

Under the RARES project, processing was monitored during the last two mullet fishing seasons (2007–2008 and 2009–2010). It was found that processed mullet tonnage rose from 17 tonnes in the 2007–2008 season to 30 tonnes in the 2009–2010 season (Ould *Mohamed Mahmoud et al.*, 2010). Bottarga turnover generally varied based on two factors, namely bottarga quality and the target market. In 2012–2013, the bottarga quality was high and the market demand was favourable, which explains why a high turnover was earned (MRO 16.1 million)[15] despite low bottarga production (140 kg).

[15] MRO 16 million equals €42 105.

FIGURE 5
Bottarga production by season and total turnover of flathead grey mullet by-products (bottarga, oil, *tishtar* and *lekhlee*)



Source: Ould Hada, 2013.

DISCUSSION

Recent fishing dynamics in the PNBA area have been marked by two major developments. First, technical change, as illustrated by the use of the *lanche*, drove Imraguen fishers into operating modes that signalled the end of their traditional subsistence shore fishing. Second, the globalization of fish products led unavoidably to the entry of the fishery resources of the Banc d'Arguin into the global market, despite the area's national park status. Most of the development projects implemented to support the Imraguens in the park were based on three observations: 1) households were very poor; 2) dependence on the income from the sale of fishery resources not consumed locally (selachians) was increasing; and 3) capacity for marketing and adding value to edible resources was lacking. Although the donors sought to raise the park communities' living standards, they rarely foresaw the irreversible effects such projects would have on the local society (defensiveness over identity and loss of traditional values) and economy (development of a commercial mindset and the widening of social inequality).

In terms of fishery resources, the effects of increased fishing by the Imraguens on PNBA stocks are very slight compared to the effects of small-scale coastal fisheries on fish stocks (SSF). Annual catches in PNBA only account for a little over 3 500 tonnes (3 percent) of the total annual catches in the Mauritanian exclusive economic zone (EEZ) of on average 160 000 tonnes. The Banc d'Arguin is, however, significant as a nursery, fattening area and/or breeding ground for the five main fishery species: flathead grey mullet (*Mugil cephalus*), meagre (*Argyrosomus regius*), Lusitania cownose ray (*Rhinoptera marginata*), milk shark (*Rhizoprionodon acutus*) and catfish (*Arius lascutatis*). According to IMROP, total annual catches in PNBA from 2000 to 2011 accounted for 13 to 14 percent of total SSF catches of flathead grey mullet and meagre, 47 percent of Lusitanian cownose ray, 73 percent of milk shark and 98 percent of catfish. With regard to catch quotas, it would appear that the park management is relying on a single lever: the need to maintain overall tonnage but at the same time reverse the trend of sizable selachian catches, using regulations that have so far not proven effective.

One thing is for sure, however. PNBA is the most effective MPA anywhere in the West African region in terms of monitoring and conservation of fish resources. The

At-sea Surveillance system set up in 2000[16] has at least partly protected PNBA fishery resources from external fishing pressure, particularly from small-scale coastal fisheries.[17] This is one of the main successes, if not the only one, that can be directly correlated to the use of *lanches* to fish; catches have been largely maintained at a total annual tonnage of approximately 3 500, with 100 *lanches* operating. Also, restricting access to the fish resources in the park exclusively to the Imraguens is in itself a major achievement and could ensure sustainable food security and subsistence. These two objectives cannot be achieved, however, unless the commercial fishing is decreased and, most importantly, the social and economic gap is narrowed between *lanche* owners and non-owners.[18] In PNBA, the relationship between food security and home consumption of produce has been upset by another objective, the pursuit of profit, which has become widespread. People no longer fish to eat and feed those who live off the resource, but only to create wealth and reinvest the capital in real estate projects in town. Annual turnover from landed fish catches is nearly MRO 600 million.[19] As the fishing economy becomes monetarized, the food security of poor Imraguen households that depend very heavily on fish in PNBA is in serious jeopardy. Fernandez (2009) highlights the fact that shipbuilding and the fish wholesale trade are in the hands of about a hundred people (some of whom no longer live in the park) who capture 60 percent of the income generated by fisheries. According to Tabiya (2012), 76 percent of income generated by fisheries, estimated at €1.7 million, is earned by the wholesalers, 19 percent by the *lanche* crews and 5 percent by the fish processors.

Fisheries in PNBA have generated wealth for the fishers and fish processors, despite the many efforts to regulate fisheries and ray and shark conservation, with Bay of Arguin being a sanctuary for more than 40 species. These species are known for their low breeding rates, due to their slow growth and late sexual maturity. Fisheries that target them could cause irreversible consequences for the Mauritanian EEZ and the entire West African marine region. According to Wagne (2009), slightly more than 80 percent of the 4 663 tonnes of rays and sharks landed by Mauritanian small-scale fisheries came from PNBA and the area located to the north of it. Shark production, as declared by the seven member countries of the Subregional Fisheries Commission (SRFC),[20] is estimated at 11 000 tonnes (EU, 2012). Senegal (6 000 tonnes) and Mauritania (4 633 tonnes) alone account for 95 percent of the region's total annual catches. These figures clearly highlight the growing threat that Senegalese-Mauritanian fisheries represent for the West African marine region's cartilaginous fish, and once again underscore the unsatisfactory results obtained by the PNBA MPA in terms of preserving this resource.

The positive outcome of support to the Imraguen fish processing industry, particularly to Imraguen women for the processing of flathead grey mullet, shows that further support for this activity would be beneficial. Being able to add value to their products boosted women's confidence in the income-generating potential of

[16] This is an innovative surveillance system, as it is based on a participatory approach involving a PNBA officer, a coast guard officer and an Imraguen representative. It has also been logistically and financially supported by FIBA since 2010 as part of the SurMer (At-sea Surveillance) project.

[17] At-sea Surveillance data show that fishing canoes have been regularly boarded and searched within the park and no national or foreign trawlers have approached MPA boundaries.

[18] The notion of equity in the PNBA fishing context relates to having the means to purchase a sailing lanche, which is the only means a fisher has to access the fishery resource. Capping the number of lanches at 114 units when there are more than 300 active fishers makes the quest for equity all the more difficult. The steep rise in lanche prices (nearly €32 000) limits the possibility for the remaining two-thirds of fishers, who are very poor, to ever own a lanche, and hence for the social and economic gaps to be narrowed and the dependence of Imraguen sailors on lanche owners, most of whom are also fish wholesalers, to be lightened.

[19] Approximately €1 500 000.

[20] The seven member countries of the Subregional Fisheries Commission (SRFC) are Cape Verde, Gambia, Guinea, Guinea Bissau, Mauritania, Senegal and Sierra Leone.

bottarga manufacturing, which could prove to counterbalance the activities of the local fish wholesalers, who wish to further control the fresh mullet industry. In order to be effective and sustainable, these industry-revival initiatives must move beyond the project stage and become programmes. The recipients of support are still too weak to stand up to the fish wholesalers, and long-term assistance would be needed to strengthen and make sustainable the Imraguens' means of livelihood.

CONCLUSION

PNBA is an exceedingly valuable testing ground from a historical, social, cultural heritage, economic and fisheries resource-management point of view. In analysing these various aspects of the park, the positive and negative effects on the Imraguens' food security and means of subsistence have been presented, albeit with due caution. A detailed analysis shows that the Bay of Arguin MPA is a provider of fisheries resources to the local population and that the food insecurity and impoverishment to which Imraguen households have been subjected is due to first, the disruption of the traditional methods of using resources by the Imraguens themselves (including the local fish wholesalers) and second, the park management and its partners whose development initiatives have not served to lessen the social and economic inequalities.

Therefore, the strategies for providing the MPA communities with livelihood support need to be rethought. The Bay of Arguin is a porous geographical entity connected to a vast national and regional network in which species of high commercial value are shipped through various channels. The experience with the meagre nets clearly showed that simply regulating the type of fishing gear to be used was not enough to stamp out illegal fishing. Also, providing support to the park fishers' trading facilities without setting up effective regulatory measures further up the line indirectly aids and abets the development of downstream industries. The facts speak for themselves: a study has shown that 86 percent of the total wealth created by fisheries in the park benefitted outsiders, while only 14 percent benefitted resident PNBA Imraguens (Tarbiya, 2012). Maintaining sustainable means of livelihoods for the Imraguens and narrowing social and economic gaps clearly depend on the efforts made to co-manage fishery resources at the MPA-level.

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The positive relationship between the Ostional community and the conservation of olive ridley sea turtles at Ostional National Wildlife Refuge in Costa Rica

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INTRODUCTION

Ostional National Wildlife Refuge (ONWR) in Costa Rica has been cited as both an excellent example of community participation in biodiversity protection (Campbell, 2007) and an example of misguided exploitation of marine resources (Spotila, 2011). ONWR is a small area in Guanacaste province in Costa Rica (from 85 43'50" W 10 01'00" N to 85 40'40" W 09 54'30" N), corresponding to the marine-terrestrial zone that includes the Ostional, Nosara, Peladas and Guiones beaches. The total area is 13 390 km^2 with 12 875 km2 of ocean and 514.99 km^2 of land. The land portion consists of an area measuring 200 m wide and 19 km long and associated wetlands. ONWR belongs to the life zone of the basal humid rain forest transitioning to dry forest. The coastal-marine view of the ONWR is shown in Figure 1.

Ostional beach is the world's second largest nesting site of olive ridley sea turtles (*Lepidochelys olivacea*). Their coming ashore in masse is known as an *arribada* (arrival) (Figure 2). This nesting behavior occurs only on the 7 km long Nosara and Ostional beaches in ONWR, while the Guiones and Peladas beaches provide conservation, recreation (surfing, swimming, etc.) and ecosystem services to local residents and visitors (Orrego, 2014).

The focus of the present paper is to document how a turtle conservation project and the Ostional community is contributing through habitat management to the conservation of the sea turtles in ONWR and promoting the rational use of olive ridley sea turtle eggs to the benefit of local people's livelihoods. This is in keeping with the theme of the sustainable use of natural resources by local communities, and the role of participation of coastal communities in the management and conservation of the ecosystems, mindful that these same ecosystems can provide benefits to ensure food security and a way of life.

FIGURE 1
A coastal-marine view of the ONWR, including the Ostional and Nosara beaches

Source: Orrego, 2014.

BACKGROUND

ONWR was established in 1983 by the Ministry of the Environment (MINAE) and the Costa Rican Institute of Fisheries and Aquaculture (INCOPESCA) to protect Ostional beach and to provide benefits and incentives to the local community to protect the turtles. ONWR's mission has always been to manage and achieve the sustainable use of this resource and to gain community support through its participation in the conservation process, including strategies such as planning, research, protection, control, ecotourism and environmental education (ADIO *et al.*, 2007; MINAE, 2003; Orrego, 2014). A key aspect has related to the local community's collection and use of olive ridley sea turtle eggs during *arribadas*, given that, since 1959, these have been a local source of food.

FIGURE 2
An *arribada* in Ostional

Source: Photo courtesy of Pablo Baltodano.

FOCUS ON CONSERVATION AND PEOPLE'S IMPROVED LIVELIHOODS USING ECOSYSTEM SERVICES

In Costa Rica, environmental laws prohibit the use of sea turtle eggs. Nevertheless, given its longstanding use of turtle eggs, and its knowledge of the ecology of the arrivals, the community of Ostional appealed to the University of Costa Rica (UCR), through Dr Douglas Robinson, to support a project to manage during the initial days of the *arribada* the collection of olive ridley sea turtle eggs, which would otherwise be destroyed by the turtles themselves due to the very high density of nesting. Dr Robinson proposed several management guidelines for the controlled exclusive collection of the eggs by the Ostional community organized through a development partnership. The collection would take place within the first 30 hours of the turtle *arribada* and only the eggs with an almost 100 percent likelihood of mortality would be collected. The remaining three to six days after the *arribada* would be dedicated exclusively to conservation and protection of the eggs and later hatchlings. In return for the possibility of collecting eggs, the community of Ostional would be required to take various conservation measures, the most important of which was the creation of a monitoring and surveillance group to prevent looting of eggs on the beach, the removal from the beach of breeding pigs which eat the eggs, the clearing of coastal vegetation, the removal of natural debris that would prevent the entry of turtles onto the beach and the salvation of neonates from predation by birds and mammals during the day (SINAC, 2015).

These proposals were in keeping with the results of social and biological studies of UCR and other national and international universities, suggesting that the ONWR population could benefit from collection of some eggs (Chaves *et al.*, 2004; Orrego, 2014). As a result of this research, in 1987, the Ostional Integral Development Association (ADIO) was formed by a general assembly of the people of Ostional and passed Act No. 7064 on the Promotion of Agricultural Production (FODEA), legalizing the collection and marketing of olive ridley sea turtle eggs by the Ostional community, and authorizing the utilization of the eggs for consumption and trade.

Subsequently, Law No. 8325 on the Protection, Conservation and Recovery of Marine Turtle Populations of 2002 recognized the right of the Ostional community to collect olive ridley eggs in ONWR, provided it is done in adherence to regulatory provisions issued by the MINAE through the National System of Conservation Areas (SINAC). In addition, Ministerial Decree No. 28203-MAG regulates the collection of eggs, while Law No. 8436 on Fisheries and Aquaculture of 2005 establishes that INCOPESCA is to regulate the marketing of the living resources of the sea and its products. In 2003, MINAE brought together government bodies and local organizations, guides and fishers to create by consensus a co-management commission to serve as a framework legally established by Executive Decree DAJ-020-2005. The commission implemented an integrated approach to identify priority objectives, solve potential problems and fulfill the goal of the mission statement, building on a basis of participatory environmental management (PEM) and community-based conservation (CBC) (Orrego, 2014).

These government initiatives have provided the framework within which the Ostional community has operated, for more than 20 years, for the sustainable use of olive ridley sea turtle eggs and for the care of the turtle breeding and nesting habitat. This effort has been led by ADIO. The overseeing of egg utilization is the responsibility of an interagency committee of the ADIO, which includes the School of Biology at UCR, MINAE and INCOPESCA. In turn, ADIO's internal organization is the responsibility of the National Director for Community Development (DINADECO).

CONSERVATION OF THE OLIVE RIDLEY SEA TURTLE

One scope of the turtle conservation project is to manage the stability of the turtle populations as well as their interaction with other species that nest seasonally. An annual management plan, based on egg collection data and an evaluation of the status of the turtle population, is required to ensure that the conservation objectives for the turtle population are met. Millions of offspring are produced annually without a nursery: this is one of the highlights of the project. By protecting neonates, their survival rate has increased by 10 percent with respect to the days when there was no protection. The maintenance of the habitat has enlarged the nesting area by several thousand square metres and ensured the quality of the turtles. (SINAC, INCOPESCA, ADIO and UCR, 2012).

In Ostional, the benefits from the marine turtles for the local people must be maximized while at the same time ensuring the best conditions for hatchling production to support turtle population stability. Conservation measures can be anchored in a commonly agreed management scheme between the government and the community.

PARTICIPATORY ENVIRONMENTAL MANAGEMENT (PEM) AND COMMUNITY-BASED CONSERVATION (CBC)

Since its inception in 1987, ADIO, with the help of UCR, have been elaborating annual work plans for the collection and utilization of turtle eggs. In 2006, they developed the first five-year management plan for the conservation of turtles in ONWR (Five-Year Plan 2006–2011). For ONWR, this management plan was important for the PEM-CBC process. It was signed by all stakeholders on 23 February 2007 (the World Day of Wetlands in Costa Rica) and renewed in 2012. It set goals for research, the protection of turtles and the management of egg harvests to insure the sustainability of the turtle population. It also summarized the advances in economic, ecological and social benefits in ONWR. It served as:

- a frame of reference for outlining guidelines and taking decisions: principles governing the plan, general and specific rules, plan objectives, progressive and cumulative goals and organizational structure;

- a framework for agreements and joint decisions between actors, indicating the contributions, investments and obligations during implementation, as well as the benefits to be enjoyed by all parties; and
- a timetable for fulfilling tasks, achieving goals and scope of the mechanism for monitoring and evaluation.

The turtle conservation project has been praised in international forums and earned recognition from the Foundation for Participatory Environmental Management (Antigua FUNGAP-Group) in 2005 as one of seven examples of an outstanding experience in PEM of wetlands in the Americas. In those seven communities awarded recognition, the environment is an integral part of their culture and survival, a situation wherein ground is fertile for promoting participatory, sustainable, "in harmony with nature" social development (Marin, Criado and Bravo, 2005).

The Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC) recognized the right of utilization of eggs for subsistence by communities such as the Ostional community (Orrego, 2014).

The participants in the turtle conservation project are the positive link between the community and olive ridley sea turtle population. Providing protection for the female turtles and their hatchlings is an important conservation activity to recover and stabilize the Ostional sea turtle population.

BIOLOGICAL MONITORING OF THE OLIVE RIDLEY SEA TURTLE POPULATION

To ensure that the proposed utilization of turtle eggs does not adversely affect the olive ridley sea turtle population, two main activities have been organized:

- a project to monitor the nesting sea turtle population in ONWR by UCR from 1970 to the present and to monitor indefinitely the 7 km of Ostional and Nosara beach for about 340 days a year (Chaves *et al*., 2010); and
- a global counting programme for olive ridley sea turtles during the *arribadas* (2006–2015).

On certain *arribada* beaches, hatching success is often so poor that the value of these beaches for sustained recruitment of the turtle population has been questioned (Cornelius *et al*., 1991; Cornelius *et al*., 2007; Honarvar *et al*., 2008). The high egg mortality is due to the very high density of nesting during *arribadas*, when the turtles themselves physically disturb 20 to 40 percent of deposited clutches. If there are successive *arribadas* before the end of the incubation period, this results in additional disturbance of *in situ* nests. Further mortality may occur as a result of proliferation of fungi and bacteria, reduced oxygen and increased carbon dioxide from microbial respiration, and an increase in sand temperature may limit embryo development (Cornelius *et al*., 1991; Cornelius *et al*., 2007; Valverde, Cornelius and Mo, 1998; Wallace *et al*., 2004; Clusella Trullas and Paladino, 2007; Honarvar, O'Connor and Spotila, 2008; Brenes, 2013). *Arribada* beaches may lose quality as optimal nesting beaches over time so that some beaches may only constitute temporary nesting habitats (Bernardo and Plotkin, 2007; Orrego, 2014).

Spatial, temporal, natural and human management measures for Ostional should include systematic and long-term monitoring of *arribada* parameters, and large-scale experiments on the effect of sand cleaning on hatching rates and hatchling production, given that clean sand is associated with increased hatching success. Sand cleaning could then be integrated into the management measures at the Ostional *arribada* beach.

As the biology of the olive ridley sea turtle *arribadas* at Ostional would suggest, a marine protected area could be an effective means both to protect nesting turtle populations and to provide socio-economic benefits for improved livelihoods of the community members. However, strict anti-poaching measures nationwide, consumer awareness about egg collection in Ostional and traceability of eggs of legal origin are

necessary components of an Ostional egg harvest scheme. The key to success, however, lies in the local ownership of the management plan and strict enforcement of the law.

ADAPTIVE MODEL OF SHARED MANAGEMENT

An important scope of the turtle conservation project is to promote community participation in support of the conservation process, including planning, research, protection, monitoring, ecotourism and environmental education (ADIO *et al.*, 2007; Orrego, 2014). To this end, the project has become a leading model for PEM, conservation and utilization of coastal resources.

The turtle conservation project has created an adaptive model of shared management that contributes to natural resource conservation of turtles as well as the sustainable use of a sensitive natural resource such as turtle eggs. The five-year management plans contain a regulatory framework with objectives, principles and rules on governance and the operationalization of the five-year management plan. These rules were drawn up jointly by representatives of ADIO, INCOPESCA, SINAC and UCR.

The management plan also sets out a number of principles that must be followed by key players, such as:

- Be a model for the utilization of resources of high environmental sensitivity.
- Harvest only those eggs at arrival that are less likely to hatch.
- Base regulations on research of turtle population dynamics.
- Internalize conservation practices to maintain the population of sea turtles and reap the ecological and social benefits.
- Seek to ensure better health and protection of the community members, children and the elderly.
- Promote the welfare of families and strengthen community management.
- Preserve the statement on ethical responsibility and values to ensure a strong belief in the model of shared management and enrichment of local culture.

It includes a regulatory framework to guide the harvesting, packaging, handling and transport of eggs, and the surveillance of the beach and surrounding area. It also includes rules for the marketing and distribution of eggs, the treatment of tourists, the organization of volunteer work and habitat management.

HARVESTING OF TURTLE EGGS

The legal turtle egg harvest is desirable from the point of view of its contribution to local livelihoods and food security, and the positive caring it generates among community members.

Harvesting is limited to the main nesting beach in Ostional, which has remained the official site. Rules for the harvesting of eggs are as follows:

1. Only the eggs of olive ridley sea turtles laid during the *arribada* can be harvested.
2. The declaration of the *arribada* will be a written document indicating the starting time and place of the mass nesting, thus initiating the collection and marketing of eggs.
3. Each month, the period in which to harvest eggs will be defined at the time of the declaration and include the daylight hours of the first two days of the *arribada* and from 5 a.m. to 12 noon the third day of the *arribada*.
4. The search for exploitable nests will be made only by means of scoring the sand with feet or hands.
5. To protect the turtles and their nests, ADIO must appoint a permanent monitoring group.
6. ADIO will ensure the protection of nesting activity according to an approved plan.
7. Collecting eggs at specified sites for experimental purposes will not be allowed
8. ADIO will conduct activities to improvement the habitat.

9. The monitoring of nesting activity will be permanent to ensure the conservation of the sea turtle population.
10. The institutions involved in the turtle conservation project are responsible for developing a communication strategy for the management and conservation of sea turtles.

PACKING AND TRANSPORTING OF TURTLE EGGS

The transport of eggs from the beach to the warehouse must be handled exclusively by people, using a synthetic fiber bag, while the transport of eggs to market must be done in licensed vehicles and regulated by INCOPESCA and SENASA (Figure 3).

FIGURE 3
Collecting and packaging olive ridley sea turtle eggs

Source: Photo courtesy of Norma Rodríguez.

Eggs must be grouped by grade and packaged in plastic bags, with each bag containing ten eggs, and each lot of ten bags packaged in a box, with a maximum of 200 eggs per box. The boxes must be sealed and stamped with the logo of ADIO. After this stamp has been used, it must be destroyed to prevent being used further.

The eggs extracted for sale may only be sold within the country. SINAC and INCOPESCA must be notified about sales for control purposes. A receipt for each sale should be issued by ADIO. Every retail egg business should have a legal permit from INCOPESCA displayed in a visible place at the business. The permit should have the stamp and signatures of INCOPESCA and will be valid for one year.

Businesses which sell eggs to the public must display external signs that identify their egg trade as legal, and raise awareness about the management model implemented in ONWR.

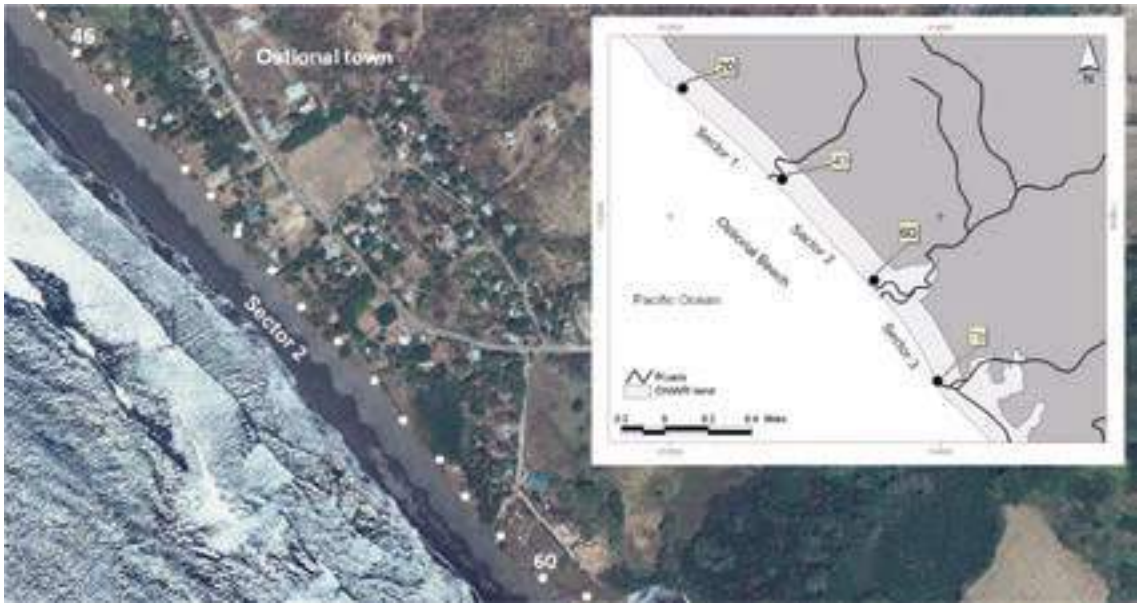
If for some reason an egg dealer withdraws from the market, ADIO must notify the respective local and regional agents of SINAC and INCOPESCA. The sale of eggs by businesses within the Ostional community shall be governed by the same rules as govern the sale of eggs by businesses outside the Ostional community. Eggs returned for any reason during marketing should be quantified. Those eggs in poor condition must be discarded in the same way as the packaging is discarded. Eggs in good condition can be donated by ADIO to social welfare institutions (schools, nursing facilities, nutrition centres, etc.). Their arrival at destination must be reported to SINAC and INCOPESCA.

Harvesting eggs for non-commercial use is permitted by residents of Ostional only when arrivals are in numbers of over a thousand turtles (Five-Year Plan 2012–2016).

HABITAT MANAGEMENT PRACTICES AND CONSERVATION ACTIONS

It can be argued that the increase in turtle arrivals on the Ostional and Nosara beaches is related to strong management. Habitat management, the limiting of egg harvesting to certain times and places, and the strict protection of nests outside the harvesting area can improve the survival rates of most nests during each arrival (Five-Year Plan 2012–2016). In Ostional, from 1959 until the early 1980s, the arrivals occurred only along a kilometre of beach between the Ostional and Nosara beaches (Chaves, 2007, Orrego, 2014) (Figure 2), while from 2002 to the present, the arrivals have gradually extended to along 7 km of the Ostional and Nosara beaches (Orrego, 2014) (Figure 4), as a result of nesting habitat management by the community.

FIGURE 4
The three sectors of ONWR measuring a total of 2 800 m.



Note: The town of Ostional is located close to sector 2.
Source: Orrego, 2014.

As part of the five-year plans developed for site management, habitat management is one of the essential tasks. This includes (1) eliminating the creeping vegetation that invades the upper part of the beach, where nesting occurs, (2) collecting natural debris such as tree trunks brought in by the tides from other parts of the territory, and which, if allowed to invade the beach, would prevent the passage of turtles, and (3) planting piñuela on top of the beach, to restrict the turtles to the beach, and away from inhabited areas. The idea is to increase the beach area available for nesting, so as not to confine the turtles. These activities are carried out every two weeks, but the frequency may be increased if necessary, for example during the rainy season (Figure 5).

The five-year management plans also include a programme to protect olive ridleys sea turtle hatchlings born in the shelter from predators or the threat of wild animals and dogs, mainly in the morning and evening, and to protect neonates in times of extreme heat. These tasks are performed mainly by women and youth every month, especially during the rainy season (May to January) (Figure 6).

To counter the illegal exploitation of eggs as well as to ensure on-site beach protection of turtles and their nests, ADIO, together with officials of SINAC and INCOPESCA, have formed a permanent monitoring and surveillance group.

As described above, the turtle conservation project includes regulations on the packing, handling and transport of eggs as well as provisions for surveillance on the beach and in the surrounding area. It also includes rules for the marketing and

distribution of eggs and for the visits of tourists to observe the community members as they collect and package the turtle eggs.

The conservation project's overall goal is to control the illegal trade of eggs from other beaches of the Costa Rican Pacific but this goal as yet has not been realized.

FIGURE 5
Removing the creeping vegetation and natural debris

Source: Photo courtesy of Gerardo Chaves Brenes.

FIGURE 6
Caring for the baby turtles

Source: Photo courtesy of Norma Rodríguez.

TURTLES AND TURTLE EGGS FOR SUSTAINABLE LIVELIHOODS AND SOCIAL AND FOOD SECURITY

Benefits for community livelihoods and food security arise in several ways – through income generation (in three ways: turtle egg harvesting, turtle observation, and turtle egg sales and investment), food security, diet diversification, community distinction and social cohesion. Each of these is discussed in turn.

Income generation: turtle egg harvesting

The turtle conservation project promotes the rational use of olive ridley sea turtle eggs to the benefit of local people's livelihoods. During three decades, many community members have played a leading role in the implementation of the turtle conservation project, organized with a view to the collection and utilization of olive ridley sea turtle eggs as an income-generating activity. Today, the vision is the same.

In 1973, the community of Ostional was inhabited by 253 people, with most engaged in agriculture and livestock raising (88.4 percent of the people). A decade later, and after a population increase of 6.7 percent, these activities has lost in importance (37.8 percent of the people), and the economy was also based on income-generating activities such as community services, construction, trade, and restaurant and hotel operations. In 2005, the main economic activity of the Ostional community was the harvesting of olive ridley sea turtle eggs.

Obviously, the economic activity of harvesting eggs depends on the *arribada*, and those who collect turtle eggs work 36 hours a month, during which time they are required to clean the beach. One person is involved in monitoring the beach 48 hours a week. Under these conditions, the population of Ostional is building its community dynamic and defining the forms of resource exploitation at its disposal to develop its economy. Many families that manage to enter the labour market opt for two occupations, the harvesting of turtle eggs and labouring in construction (men) or keeping house (women).

Gender equity is being promoted through the egg harvesting activity since both men and women are paid the same, regardless of the task that each performs. A significant percentage of women are employed in egg harvesting, but also in jobs involving cleaning and cooking in hotels and restaurants. (Astorga, Avendaño and Delgadillo, 2007).

The economic benefits are clear (Campbell, 2007): the collection and marketing of olive ridley sea turtle eggs still remain the primary economic activity in Ostional (Villate, 2008).

Income generation: turtle observation

The olive ridley sea turtles in Ostional are important for ecotourism. Ideally, the community should seek to further benefit from the development of sea turtle ecotourism, and to share the responsibility and benefits as widely as possible within the community to avoid the creation of small monopolies (Orrego, 2014). Olive ridley sea turtle nesting during the *arribada* is a spectacular event with a great marketing and income-generating potential. In general, nesting of solitary females can be frequent enough to provide a reliable ecotourism experience on most nights. For Ostional, therefore, a well-managed harvest of doomed eggs and ecotourism could be a winning combination for the generation of income for local residents and for increased hatchling production (Figure 7).

Ecotourism in Ostional is just beginning but is seen by the community as a great opportunity for income-generating activities, such as providing accommodation and food, as well as tour guide services for observing turtles, as regulated by the Regulation for Public Use of ONWR No. 32627. A job as a tour guide pays better than egg harvesting. Members of the local guides association became strong supporters of the ONWR and PEM. In 2002, 20 local residents decided to work in ecotourism, and

FIGURE 7
Tourists watching a turtle accompanied by a local guide

Source: Photo courtesy of Erick Vargas.

today this number has grown to 40 residents. In the period 2003–2014, they raised approximately US$682 000 from tour services. They support all ONWR management strategies, and help in conservation. They conduct tours to the nesting beach and at the same time patrol the beach, clean the beach of debris, improve the habitat and protect the hatchlings as they head for the sea from dog and avian predation. Ecotourism is a good source of income.

It is important to be aware of what the ideal number of visitors to the beach at any one time should be so as not to cause disturbance to the turtles, the opportunities for participation of the local people in the conservation project and the impacts on wildlife (Campbell, 2007). The shift in mindset to the indirect utilization of resources through ecotourism is difficult and slow for cultural reasons but ecotourism can offer a good alternative to other income-generating activities. Work opportunities in addition to ecotourism must be found that provide at least as much income as egg collection (Orrego, 2014).

Volunteers come from all around the area to work to support the conservation of olive ridley sea turtles and other marine turtles such as the leatherback and the black turtles. They are paying guests in various homes in the community throughout the year, and thus contribute to local household income (Villate, 2008).

Income generation: turtle egg sales and investment

Over the last five years, ADIO has allocated approximately US$248 000 from the sale of eggs to community infrastructure development. It has built most of the communal buildings, including educational, health and administrative facilities, as well as roads and pedestrian suspension bridges, and provided guardrails on rural roads and Ostional Quebrada Seca booths for tour guides (Villate, 2008). Investment in community infrastructure improves the well-being of the whole community (Villate, 2008).

Thirty percent of earnings from egg sales are invested in community works, administrative tasks, monitoring and research.

Because the community members perceive education as important and, in general, children for the most part receive a primary education, ADIO invests part of the egg sale earnings in improving school infrastructure. Telesecundaria is a secondary school programme with instructors who teach using audiovisual aids. It awards ADIO scholarships to needy students to study even at the university level, although college attendance is difficult due to the long distances to schools and limited economic resources. Those who fail to enter the formal education system opt for courses in sewing and English, and training as tour guides (Astorga, Avendaño and Delgadillo, 2007).

Allocations for social benefits include pensions for those over 65 years of age, and subsidies for periods of maternity, sickness and disability.

Half of the population of Ostional is eligible for membership in ADIO and 201 people, or 44 percent of the population, have joined: 108 members are men and 93 members are women. To join ADIO, one must be at least 15 years old and must have lived for more than ten years in the community (Astorga, Avendaño and Delgadillo, 2007). Earlier, people aged 45 or over played the leading role but today a minority of members are over 45 years and most are between 15 and 29 years, constituting a great potential for the future (Astorga, Avendaño and Delgadillo. 2007). The members of ADIO are eligible to be part of the community workforce that cleans the beaches, cares for the turtles and properly collects eggs, and also to receive proceeds from the sale of eggs, which are distributed equally among partners.

It should be noted that the interests of the young people of Ostional do not revolve solely around egg harvesting. The socio-economic dynamics have included an increase in immigration from 2000 to 2005, giving impetus to the ecotourism sector.

Food security

The turtle eggs are important as a source of food and trade. In Ostional, each family is entitled to 200 eggs during each *arribada*, while each nearby community (Lagarto, Marbella, Nueva Esperanza Garza, Nosara, Peladas and San Juanillo), receives 100 eggs per family. The rest is sold in the local market by ADIO's partners. Seventy percent of the proceeds from the sale of eggs is distributed equally to ADIO members involved in egg harvesting.

Diet diversification

Turtle eggs allow for diet diversification: they can be used, for instance, to make cakes and breads, or for the traditional dish of tomato sauce, raw egg yolk and spices.

Community distinction

In community surveys, residents expressed the belief that the olive ridley sea turtle is a benefit to Ostional for not only its economic value but also as a symbol of the community, which sets it apart from other communities. Ostional is proud to be a community recognized by scientists and tourists for its turtle *arribada*.

Social cohesion

The high level of participation in conservation activities (e.g. cleaning the beach and protecting neonates) promotes social cohesion and collective identity among community members. Seventy-five percent of all respondents in a survey carried out by the project attributed the importance of marine turtles for this community to social and cultural factors, namely an "identity and image" which are unique to the area.

OUTCOMES

The ONWR dual mission has always been to manage and sustainably use the turtle and turtle egg resources to promote community participation in support of the conservation process, including planning, research, protection, monitoring, ecotourism and environmental education (ADIO *et al*., 2007; Orrego, 2014). To this end, the conservation project has become a leading model for PEM, conservation and utilization of coastal resources. Its success lies mainly in the commitment of coastal communities such as Ostional to care for the resources because they see the direct benefits this commitment brings. They receive benefits from sustainable resource use, i.e. an added value, which goes beyond that obtained by other communities not involved in such a project.

From an environmental point of view, the conservation project's management plan and conservation based on an adaptive process have delivered major strategic results in the annual production of millions of hatchlings of olive ridley sea turtles and in the improvement of the nesting habitat of all species of sea turtles in the ONWR, including leatherback and black sea turtles.

From a social point of view, the conservation project continues to provide a livelihood for more than 120 Ostional community residents who engage in egg collection. It has strengthened the cooperative spirit of the beneficiaries.

From an economic point of view, Ostional's responsible fishing marine area managed by its residents with the support of INCOPESCA, and thereby generating sustainable economic benefits, serves as a model for other fishing communities utilizing fishery resources in the region, such as San Juanillo. In terms of tourism, the phenomenon of mass nesting of sea turtles is so amazing that visitors are drawn to the site in large numbers and as a result guided tour revenues may well increase.

The challenge for the new generation is to be found in the conservation of habitats and species, and in the creation of activities to improve the social environment and the economies of communities, which often lack the necessary conditions for overall well-being.

Overall, local governments responsible for wilderness areas, especially coastal ones, should seek to involve local communities, many of whose residents live marginally, in the conservation and sustainable use of their respective resources and ensure to the communities the direct benefits deriving from them.

Communities should seek models such as that of Ostional, which allow access to resources, and in return require that use is regulated to ensure the sustainability of the resource. Notably, the local model continues to be sustainable, is easily replicated by other resource users such as the fishers in the area and will serve to inspire the creation of other participatory models that integrate use and conservation. Project monitoring and evaluation to learn what went right and what went wrong will allow project participants to adapt the Ostional model. This is the key to project success, along with the success of the principle that eggs "be harvested only from nests where there is evidence that hatching success approaches zero due to the high density of nesting turtles" as is at the core of collecting and marketing this resource (Five-Year Plan 2012–2016).

CONCLUSIONS

When access to resources, or the services they can provide, is denied, the motivation to conserve may diminish. Furthermore, this denial creates a huge barrier between protected area management and local communities, who view protected areas and the officials who serve to protect, as their enemies and cause of misery. As a result, people may make illegal use of resources.

When protected areas are created, it is important not only to clearly define the objectives of the conservation project but also to study the communities that live in the area or in peripheral areas, to see how they live, what their traditions are, how dependent they are on natural resources and what the potential is for integrating the goals of resource protection and community subsistence – least the territory be preserved at the expense of local community survival. Also, those conservation models that support communities in assuming new challenges such as ecotourism should be explored. In taking on new challenges, community members may need training and instruction in the dynamics of teamwork, as well as the support of government and development institutions.

The ways that local community members perform their jobs need to be reviewed and performance improved to ensure that environmental destruction does not occur when gathering food, be it turtle eggs, farm produce or a fishery resource: resource use can be sustainable if it is regulated and responsible, always aware of what resource is available, when it is available and how to access it. A case in point is Ostional, a fishing community with a harmonized plan for the management of the fishery and the conservation of turtles, and the biological monitoring of the resources, which has led to successful environmental, social and economic outcomes.

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Integrating conservation and development in Madagascar's Marine Protected Areas

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BACKGROUND/PURPOSE

Less than 3 percent of the oceans are covered by marine protected areas (MPAs), and this percentage is even lower in Madagascar (less than 1 percent). And yet Madagascar's seas are extremely diverse, with some of the largest coral reefs in the world. Simultaneously, over 10 million of Malagasy people, or 50 percent of the population, live near the coast and rely on marine and coastal ecosystems for food and revenue. Madagascar's small-scale fisheries sector is highly significant for the country (Le Manach *et al*., 2012). Countrywide, marine fisheries provide an income estimated at over US$160 million annually (World Bank, 2003) whereas the small-scale fisheries account for 70 percent of the total production and involve about 100 000 people (Le Manach *et al*., 2012).

Evidence of recent declines of fishery resources, especially species of high value, such as shrimp, sharks and sea cucumbers, has been documented (Le Manach *et al*., 2012; Anderson *et al*., 2011), and most of the small-scale coastal fisheries in Madagascar are considered unsustainable. This is largely due to overharvesting and destructive fishing practices (Iida, 2005; McVean, Walker and Fanning, 2006; Barnes and Rawlinson, 2009; Davis, Beanjara and Tregenza, 2009; Brenier, Ferraris and Mahafina, 2011; Le Manach, 2012; Robinson and Sauer, 2013).

Management actions in Madagascar have primarily focused around community-based fishery management strategies to increase fish stocks and reduce fishery effort. In the past decade, the number of site-based local fisheries management initiatives, also called locally managed marine areas (LMMA), in Madagascar has increased dramatically. These are formalized through social code (known as *dinas*), developed and enforced at the local level, and focus on empowering local communities to be able to take greater responsibility for marine natural resources management and ensuring closer alignment with local populations' interests. The practice of regulating fisheries by conferring management rights and powers to local communities holds great potential for sustaining dispersed small-scale fisheries and improving people's livelihoods. LMMAs in Madagascar place local communities at the center of decision-making and the management processes. The main objectives of the LMMAs are biodiversity conservation, poverty alleviation and enhancement of the sustainability of the fisheries. Most of the LMMAs implement management measures such as: no-take zones, temporary fishing closures, and gear and species restrictions, as well as activities to facilitate alternative livelihoods.

This coincides with the recent progressive shift in the policy of the Madagascar Government from centralized to decentralized management of marine resources. For instance, the new National Strategy for Good Governance of Marine Fisheries in Madagascar (Ministère des Pêches et des Ressources Halieutiques, 2012) identifies the development of local fisheries management plans and collaborative management arrangements as priorities to improve management of small-scale fisheries in Madagascar. In addition, Hery Rajaonarimampianina, President of Madagascar, committed in Sydney, Australia, at the 2014 IUCN World Parks Congress, to triple MPA coverage and reaffirmed Madagascar's commitment to achieving the Aichi Biodiversity Targets. In April 2015, for the first time in Madagascar, a few LMMAs were granted national MPA status (including the Ankivonjy and Ankarea MPAs in the northwest of Madagascar). Processes are currently underway to propose an additional series of locally managed MPAs throughout the rest of the country.

While the nation's first MPAs, managed by the parastatal Madagascar National Parks, were principally established for biodiversity conservation, scientific research and recreation, most of the new MPAs (IUCN categories V or VI multiple-uses sites, under Madagascar's protected area system) emphasize a balance between conservation and sustainable use of natural resources, and focus on empowering local communities to take greater responsibility for marine resources management. Working toward these goals necessitated the development of new models for MPA creation and management.

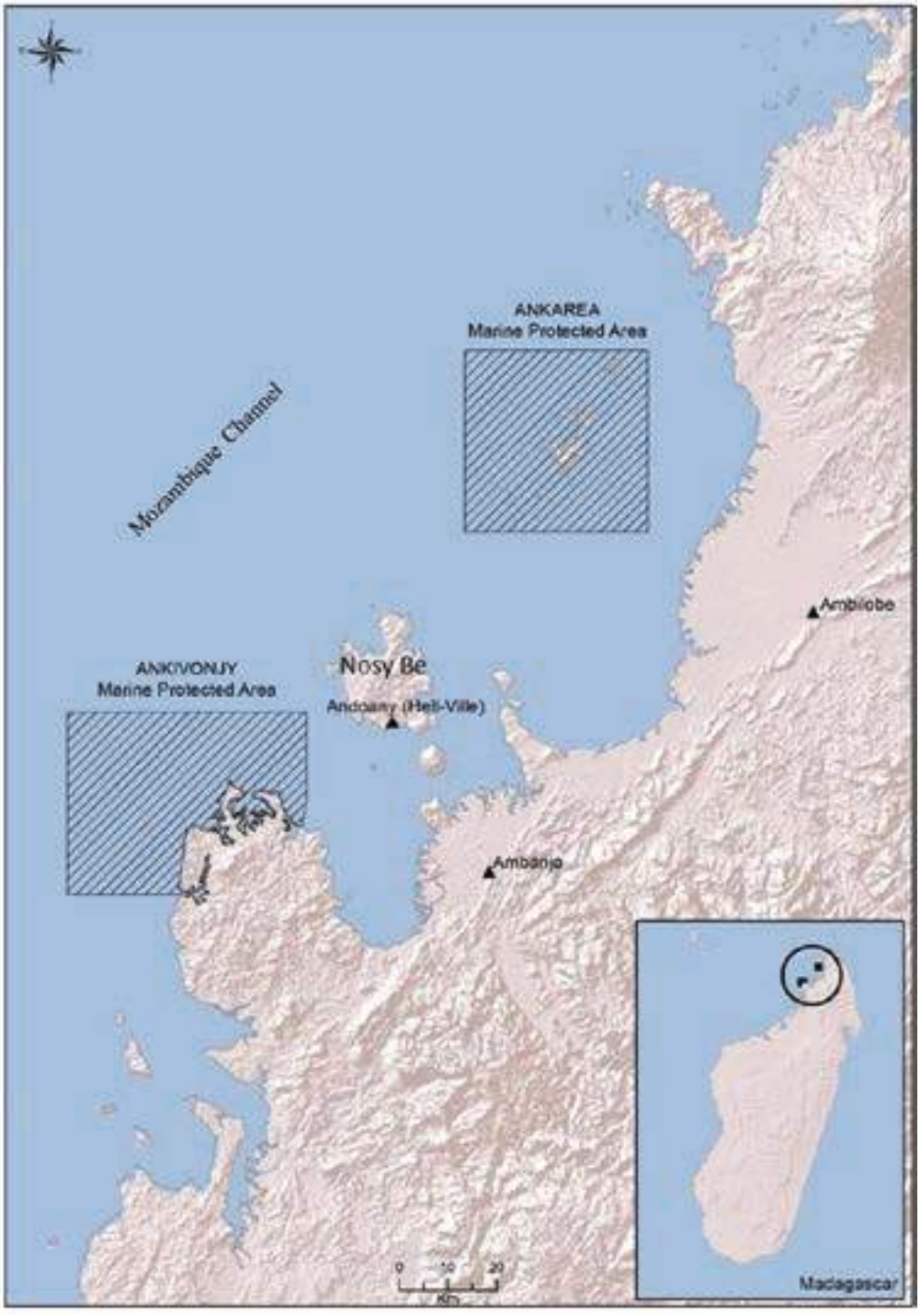
To address these challenges, an international conservation NGO (Wildlife Conservation Society [WCS]) and a French development NGO (Groupe de Recherches et d'Echanges Technologiques [GRET]) have been joining forces in the Ankarea and Ankivonjy MPAs to build and showcase a successful model for Madagascar's growing number of MPAs that integrate biodiversity conservation, poverty reduction and community-led management of marine resources.

The Ankivonjy MPA covers a total area of 139 409 ha and is located 50 km southwest of the island of Nosy Be. It includes a dozen villages and hamlets. The Ankarea MPA covers a total area of 135 556 ha and is located 50 km northeast of Nosy Be. It includes nearly 25 villages and hamlets.

FIGURE 1
Nosy Iranja in Ankivonjy Marine Protected Area

Source: Photo courtesy of Ambroise Brenier.

FIGURE 2
Localization of the Ankivonjy and the Ankarea MPAs



Source: WCS, 2015.

This paper will describe how WCS and GRET are working to ensure positive impacts on both conservation, and local communities' food security and livelihoods.

WHAT WAS DONE AND HOW

Since 2010, WCS has worked with local communities and government partners to establish the Ankarea and the Ankivonjy MPAs through a participatory approach. Key to the MPA planning process in northwest Madagascar was the implementation of two parallel processes: scientific information gathering, together with a process of community and stakeholder engagement. The five steps highlighted below have proven to be crucial to guarantee effective community and resources user engagement in designing effective MPAs that should ultimately both protect marine biodiversity and provide sustainable livelihoods benefits.

1. **Socio-economic and ecological assessments of the Ankarea and the Ankivonjy sites**

Since 2011, fine-scale scientific studies have been conducted in the Ankarea and the Ankivonjy sites to provide recommendations on the design and development of future regulations and management plans for both MPAs. Underwater coral reef assessments were conducted in both the MPAs in 2011 and 2015 (WCS, 2011; Randriamanantsoa, 2012; Jadot, 2015). Results of the studies show that the reefs of the Ankarea and the Ankivonjy MPAs are in good condition and have biological and ecological characteristics that enable them to survive or recover well from bleaching disturbances.

In addition, interviews with fishers in coastal villages and small-boat surveys have been conducted by WCS between 2011 and 2014, assessing marine mammals and marine turtle species diversity, distribution and conservation status (Cerchio *et al*., 2014; Jean, 2012). Work in the Ankivonjy MPA revealed particularly high cetacean diversity (12 species sighted), likely due to the diversity of habitats and presence of deep water.

These studies have shown that these sites harbour some of the most diverse coral populations on the planet, important nesting sites for marine turtles and critical habitats for diverse, abundant and endangered cetacean populations (including humpback whales, blue whales, sperm whales and beaked whales).

In 2011, semi-structured interviews with key informants and household surveys (Baker, Rasoanandrasana and Saula, 2011; Rabearisoa, 2012) provided socio-economic information about the local communities. The two MPA areas are relatively sparsely populated, with 4 000 people living in small settlements. Fishing is one of the main livelihoods of the local inhabitants who utilize unpowered traditional canoes. Informants mentioned that fishers from outside the area (mostly from Nosy Be and the mainland) also visit the area with speedboats and generally use illegal fishing gears (such as scuba tanks) to target high value species, including lobsters and sea cucumbers. In addition, a few thousand tourists visit the two areas each year, some of them for recreational fishing. The local communities within the Ankarea and the Ankivonjy MPAs show high vulnerability because of high exposure to climatic events (e.g. cyclones), a high level of dependence on fisheries, and low social adaptive capacity (i.e. lack of social infrastructures, very low level of education). The vast majority of respondents (79 percent) are of the opinion that there is a decline of fisheries resources and a deterioration of the marine and coastal ecosystems in recent years, and 69 percent of these people attribute these degradations to anthropogenic activities, such as the use of destructive fishing gears and an increase in the number of fishers over the years (Rabearisoa, 2012).

These studies revealed that marine ecosystems of the Ankarea and the Akivonjy MPAs support both high biodiversity and local livelihoods of vulnerable communities.

2. Awareness-building and communication

In each community, outreach and education programmes have been implemented to increase fisher's understanding of sustainable fishery management, improve coastal fishery stewardship, ensure widespread compliance with existing fishery regulations and promote the adoption of more sustainable fishing practices. This will include the diffusion of existing regulations and benefits of fishery management through the production and distribution of a local magazine, information panels, briefing in the villages, and radio and television broadcasts, the organization of a marine turtle festival and the initiation of an environmental education programme targeting youth and school children.

FIGURE 3
Community meeting to discuss the design of Ankivonjy Marine Protected Area

Source: Photo courtesy of Ambroise Brenier.

3. Development of fishery management and enforcement plans

During a series of community meetings, management actions have been designed based on on-site discussions and on the socio-economic and ecological information that have been collected for the sites.

Along with the scientific studies described above, a process to engage stakeholders directly in the MPA planning process was implemented. After a series of informal consultations, an inception workshop was held with a range of stakeholders, including regional and national authorities in 2010 in Nosy Be. This allowed for the further identification of priority areas for intervention in the northwest and to officially launch the proposed establishment of two MPAs in hotspots of resilience in the northwest, which eventually became the Ankarea and the Ankivonjy MPAs. Following the workshop, an MPA steering committee was established to oversee and monitor the implementation of the two MPAs and to encourage cross-sectoral coordination. It consists of representatives from WCS, local authorities, administration staff, tourism operators and fishing communities.

Since 2010, regular meetings and consultative workshops have been organized to discuss and adopt MPAs' goals, boundaries, zoning, regulations, and governance and management activities through a participatory approach involving all stakeholders. Thus, at the beginning of the process, a series of workshops in each village were

organized, during which local communities were able to present their vision for the sustainable management of fisheries resources, while trying to develop a zoning plan and an outline of the management plan fitting their needs and local realities. This approach was adopted precisely in order to highlight both the specificities of each community and area. Then, two public consultation workshops in each one of the MPAs was organized in July 2012, where each village shared the results of their discussions, WCS shared the results of scientific studies, and the communities from each village, with the assistance of local authorities, WCS technical staff and stakeholders, started a discussion on the arrangements relating to the two MPAs. During these workshops, the participants identified key issues to be addressed, developed a vision and goals for their MPA, defined operational objectives, identified MPA zoning and rules, and choose the type of governance system and the IUCN category of the MPA. Based on the outputs of these discussions, both MPA management plans were drafted and two workshops were organized in the Ankarea and the Ankivonjy MPAs sites in October 2012 to validate each MPA management. Then, in December 2012, a workshop was organized in Nosy Be to present the two MPA management plans to regional and national authorities. The MPA management plans were then adopted by the government in 2014.

The communities and the government decided that both MPAs fall into IUCN protected area category V (Protected Landscape/Seascape). The choice of this category was driven by the desire to protect the integrity of the rich ecosystems, put the communities at the centre of decision-making and management of natural resources, promote sustainable socio-economic development, and enhance local culture and traditions. The main goals for both MPAs are the protection of biodiversity, cultural heritage and ecological services, and the promotion of sustainable socio-economic development to contribute to poverty reduction. Main strategies identified to achieve this goal are: i) maintain the ecological integrity of the natural landscape of the MPA and meet the needs of the local population through the promotion of the sustainable use of marine resources, the enhancement of local culture, and biodiversity conservation and ecosystem services protection; ii) improve the conditions and living standards of neighboring communities through the promotion of socio-economic development in harmony with nature and the preservation and enhancement of their social and cultural identity; and iii) establish and maintain a system of operational management, based on the traditional system of natural resource management, and infrastructure necessary for effective management of the MPA.

Through this process, the communities identified suitable fishery management measures that can rebuild stocks for key fisheries. The management measures have been locally designed to ensure closer alignment with local populations' interests, including permanent no-take zones, fishing gear restrictions, a ban on industrial fishing, and management of fishing capacity. All these management measures have been adopted at the national level and included in the legal tools for the MPA, such as the MPA management plan and the decree. Currently, a strategy is being tried in the Ankivonjy and the Ankarea MPAs, whereby local fishers will be granted exclusive access rights to fishing areas inside the MPAs through the delivery of individual fishing licenses to local fishers. This is a novel approach in Madagascar, which by securing use rights of fishing areas for local communities, seeks to incentivize communities to properly manage "their" resources, as it should lead to direct benefits to them, such as increased catch over the long term.

As a result of this participatory planning process, in the two MPAs, their coral reefs, mangrove habitats, and megafauna, species such as marine mammals, sea turtles, whale sharks and manta rays, have been identified as requiring protection, and specific regulations were put in place, such as the prohibition of coral extraction and the ban

on mangrove use for commercial purposes. Access to fishing areas and use of fishing gears have also been specifically regulated so that marine resources may ultimately be sustainably harvested by local communities. Large-scale fishing operations are prohibited to avoid depletion of resources and secure local livelihoods (see enforcement below). Another impact of local community involvement in the design of the MPA is that they decided to establish 100 square miles of no-take zones in biodiversity hotspots and important cultural areas outside of their main fishing areas, which are surrounding their villages.

FIGURE 4
Local fisher in Madagascar

Source: Photo courtesy of Ambroise Brenier.

4. Building of local capacities

As in most countries where FAO works, local capacities are very low, necessitating heavy investment in building capacities of local communities and government to increase their ability to effectively implement, enforce and monitor fishery co-management plans.

Through this project, local community structures, such as the Ankivonjy and the Ankarea community associations, have been legally established to facilitate the inclusion and capacity-building of local communities in the MPA planning and management process.

In addition, a pioneered community-based, collaborative law enforcement system is also being developed and tried in both MPAs. As part of the collaborative law enforcement model, a local patrol committee, called the CCS (Control and Surveillance Committee) has been established in each marine park and consists of 40 people from all the villages of the two marine parks who volunteered to become local rangers. In 2015, the 40 local rangers were trained, equipped and formally empowered by government authorities through the allocation of official badges from the Ministry of Fisheries. The new partnership between the national government and local rangers has already shown results, with five illegal nets seized in Ankivonjy marine park in May 2015. This community-led law enforcement system could be expanded to other MPAs and fishing communities, and may provide a suitable solution to the challenges of enforcing fishery and marine conservation laws along Madagascar's extensive coastline, where government presence and resources are very limited. But, as this is a very new initiative, before it can be expanded, an analysis of its effectiveness in the Ankarea and the Ankivonjy MPAs is needed.

In order to build local capacities, community representatives from the Ankivonjy and the Ankarea associations and the CCS have participated in several trainings and exchange visits.

5. Secure legal framework

WCS has worked with the national government to develop the legal framework for the management and enforcement plans and local governance structures.

To enact the rules of access to resources at the local level in the Ankivonjy and the Ankarea MPAs, communities developed *dinas*, which were approved by the local authorities and the court in March 2014.

In addition, the legal framework for the management of marine resources in the Anakarea and the Ankivonjy MPAs was strengthened through the formalization of their permanent status as protected areas. The gazetting of these areas will hopefully improve the management of marine resources by specifying regulations at the national level (a new decree was issued for each MPA), which complements the locally adopted *dinas*. The formulization of the MPAs included environmental and social impact assessments of the community-managed MPA projects in Ankivonjy and Ankarea in June and July 2014 conducted by the National Office for the Environment (ONE). Based on these assessments, ONE delivered the environment permits for the two sites in November 2014 which led to the drafting of the permanent MPA status decrees during the end of 2014 and early 2015, based on the approved management plans. Once all these mandatory steps to gain definitive protection status were successfully completed, on April 21, the Malagasy Government granted permanent protection to the Ankivonjy and the Ankarea MPAs, the country's first locally managed MPAs. This legal status provides a critical framework for the long-term sustainability of these MPAs.

6. Ensuring food security in an MPA: selecting activities to be supported

GRET has been working in the two MPAs since March 2013 to improve the communities' living conditions and sources of income. During the first six months of the project, it conducted an assessment of local agricultural dynamics. A round of qualitative surveys among households allowed for the identification of livelihood and income earning activities practiced and their contribution to households' food security and income, as well as the difficulties faced by households and how these change over time. The surveys showed that the livelihood strategies of the residents in the MPAs include fishing, agriculture and animal husbandry, with the majority practicing two or even three activities concurrently: 71 percent of the households reported being mainly farmers; 16 percent mainly fishers; and 54 percent reported practicing those two activities together (Desbureaux, 2015).

TABLE 1
Inventory of households' agricultural activities

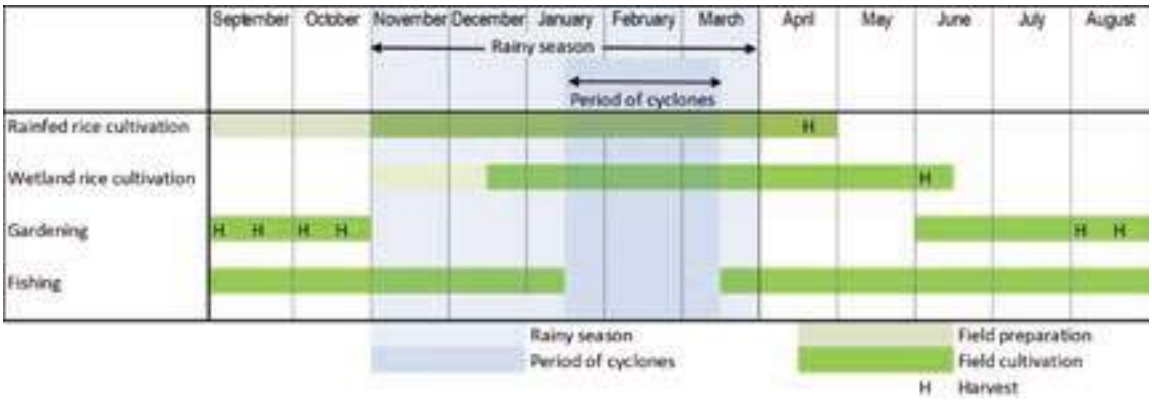
		Secondary activity						
		Agricolture (%)	Fishing (%)	No other activity (%)	Animal husbandry (%)	Other (%)	Forest (%)	Total (%)
Main activity	Agricolture (%)	–	41.8	14.8	9.8	3.3	1.6	71.3
	Fishing (%)	12.3	–	1.6	0.0	0.8	1.6	16.4
	Other (%)	4.1	0.8	5.7	0.8	–	0.0	11.5
	Animal husbandry (%)	0.8	0.0	0.0	–	0.0	0.0	0.8
	Total (%)	17.2	42.6	22.1	10.7	4.1	3.3	100.0

Source: Desbureaux, 2015.

Agriculture has a primordial position as perceived by households because rice plays an important role in households' food self-sufficiency in these remote areas that are accessed only by boat. A review of households' strategies and activity calendars shows a strong link between fishing and agriculture. Agriculture is largely extensive in nature, using small inputs of labour, fertilizers and capital, relative to the land area being farmed, and has limited and highly variable yields. Few households produce enough rice for their own needs, and most of them increase their fishing effort to be

able to buy enough rice to cover their needs. Thus, fishing catches are mostly used for self-consumption or subsistence with some amounts sold to pay for the purchase of basic commodities, namely rice. The information that came out of the surveys also stressed the seasonality of people's activities (many seasons are favourable to fishing, while the agricultural calendar is binding at very specific times of the year).

FIGURE 5
Main agricultural activities calendar



Source: GRET surveys carried out in 2014.

Agricultural production is very little diversified. People in Ankera were generally not practicing gardening before the project initiated activities. Crop and animal farmers have access neither to technical advice nor to agricultural inputs such as seeds, phytosanitary products or equipment. Their activities are also strongly impacted by climate change, materialized by a decrease and delay in rainfall in this area (Directorate General of Meteorology, Climate Change Analysis Group University of Cape Town, 2008). As a consequence, many households' diets are poorly varied (rice and fish mostly) and are highly influenced by climate hazards occurring within the year or across years.

As shown by a survey conducted by GRET in 2014 (Desbureaux, 2015), households resort to food rationing (especially for rice and fish) during the *asara* period, such rationing concerning, in particular, rice: 37 percent of the households on average reported shifting from big quantities consumed to little quantities consumed during the *asara* period (idem).

Further to the assessment, GRET and the communities established a list of support actions that were discussed with WCS. The suggested activities were classified based on a number of criteria, in collaboration with WCS and the communities: number of households that may be reached with the activity, environmental impact, initial investment required, technical complexity, competencies available among staff, proximity of exchange visit sites, activity requiring community organization, time until results are obtained, results from past experiences and major constraint or limiting factor that is enough to prevent from embarking in the activity. For each of the selected activities, GRET agreed to provide technical training and close follow-up from technicians, while facilitating and covering part of the cost of inputs and small equipment. Some activities were excluded due to their potentially negative impact on fishery resources, namely support for the procurement of traditional canoes, which could increase capacity in the fisheries, and fishing gears, and for training in longline fishing, which may have a detrimental impact on protected species.

The activities that were jointly preselected were presented and discussed during community assemblies in order to make a final selection of actions to be supported by the project.

TABLE 2
Summary of the outcomes of the process to select activities to support

Field of intervention	Actions pre-identified by GRET further to the assessment	Outcomes of consultations	Main reason for dropping
Agriculture	Rice farming intensification	Supported	–
	Development of market gardening	Supported	–
	Cassava farming intensification	Supported	–
	Cash crops (coconut, cashew)	Rejected	Too few people involved, remoteness, cashew shrubs diseases, long-term results
	Animal farming (immunization, feeding)	Supported	–
Access to basic services	• Water supply	Studies underway	Detailed and summary design
	• Rehabilitation of schools	Rejected for the time being	Access to safe water prioritized
Diversification of fishery resources	Sea cucumber raising	Supported	–
	Crab raising	Rejected by community	Inconclusive outcomes from past experiences (technical difficulties, material problems)
	Lobster raising	Rejected by GRET	No effective legal techniques
	Algae production	Rejected by community	Inconclusive outcomes from past experience (low prices, theft)
	Support to processing and marketing	Studies underway	Need to better appraise market needs and ways to address the issue of remoteness
	Facilitating access to fishing gear (boats, longlines)	Rejected for the time being	Risk of increasing fishing effort and bycatch of protected species
Development of ecotourism	Mangrove tour	Studies underway	–
	Hospitality/catering	Studies underway	–
	Crafts/embroidery	Studies underway	–

Source: GRET surveys carried out in 2014.

FIGURE 6
Rice field in Ankarea Marine Protected Area

Source: Photo courtesy of Eric Andriantavy.

The activities selected at this stage focus on the development of crop production and animal farming that would improve households' living conditions, while limiting their reliance on fishery resources and, thus, the pressure they exert on these resources.

The project has a limited number of staff (two persons per zone, working respectively on development activities and on conservation activities) who has to spend quite a significant amount of time traveling in canoes between villages. Development activities are deployed in a gradual way: in a first stage, the project supports a limited number of pilot farmers who test the changed practice or a new activity proposed for one or two production seasons, depending on the activity's level of technicality and the amount of investment required. Through this first test, the project can make improvements or adjustments to the practices prior to their wider dissemination. It also organizes exchange visits on pilot plots, as well as participatory assessments of the production season.

Infrastructure and large equipment, such as irrigation infrastructures, are planned to be leased to the association participating in the management of each of the MPAs. In line with this, the project has provided infrastructure for enclosures for raising sea cucumbers to the MPA association of Ankivonjy. The association will be in charge of leasing the equipment to community members in each farming cycle. It will identify locations for the enclosures and will provide the equipment against the payment of a lease fee. The entitlement to this arrangement may be conditional on compliance with the MPAs' various regulations, should target those community members who are the most affected by the rules (namely, youth) and should reward those who have been abiding by the rules (for instance, by excluding from the arrangement people who have been sanctioned over the last couple of years).

DISCUSSION

Trade-offs between conservation and development

Some trade-offs between conservation and development are challenging. For instance, one of the main leverages to improve short-term food security could be to develop the fishing capacity of local fishers. Members of the associations initially requested support for the procurement of traditional canoes (with or without engines) and for the diversification of fishing techniques (longline fishing, namely). However, during the discussions on the study findings, the project decided not to facilitate the procurement of such materials. The project did not choose to support the development of the local fishery as a priority activity as to do so may increase pressure on fish stocks. One of the main reasons local communities were onboard with the project to establish an MPA in their area was their perception of a recent reduction of fish catch. One of the main objectives of the MPA is to stop the decline of local fisheries. As the MPA has just been recently declared (in April 2015), the project decided to take a precautionary approach and assist the local communities in developing other sectors, such as aquaculture and agriculture, instead of supporting the development of local fisheries that would increase fishing capacity and may have detrimental effects on both fish stocks and protected species through bycatch. Comparisons of reef surveys conducted in the Ankarea and the Ankivonjy MPAs in 2011 and 2015 show that fish biomass dropped during that time (Jadot, 2015). The drop in the fish biomass since 2011 is probably due to an increase in the number of traditional fishing boats and of migrant fishers, as well as sport fishing boats in the region. This highlights the need to implement proper surveillance and enforcement of both MPAs and to build capacities of local community associations to effectively manage the fishery before providing additional boats and fishing gears.

Rather, the project has thus far focused on supporting aquaculture activities, namely the farming of sea cucumber as an initial activity. This activity has triggered some interest as demand is high (especially on the Chinese market), the resource has been deteriorating, and income can be high. However, it comes with its share of risks (theft, diseases), and the flow of income from this activity is clearly less steady than with fishing (no more sea cucumbers after nine months). Therefore, it cannot be taken as a full alternative to fishing activities, at least in a first stage.

Link between development and conservation activities

Development activities go towards a threefold objective: 1) offset the loss of income that may be caused by some restrictions associated with the setting up of MPAs; 2) provide alternatives to practices that have negative impact on marine resources in the MPA; and 3) foster benefit-sharing that is perceived as fair by all stakeholders (and especially households around the MPAs).

It is, therefore, crucial that the beneficiaries of project actions understand the link between development actions and conservation actions associated with the MPAs. Yet, several external surveys (Desbureaux, 2015; Gabrié, Rambinintsaotra and Rasoloarison, 2015) have shown that this link is not clearly seen by households.

Several mechanisms, such as the leasing of infrastructures for enclosure by the MPA association of Ankivonjy, are being designed to address these difficulties but their impact cannot yet be measured.

Another solution that has been explored is the payment of premiums by buyers interested in products produced by the MPA communities. This currently applies to the marketing of garden products and may be extended to crafts, which may be successful if buyers are tourism operators that want to preserve the MPAs as well as their image. The system would be more difficult to apply to fish products as the intermediaries who purchase products from the fishers are not interested in the MPA's image and sustainable management of fishery resources for the time being. Such premiums would only generate limited income and there is the risk that producers would feel that they are being taxed for the benefit of the MPA.

Ecotourism is an activity that has the potential to provide linkages between development and conservation, and sharing of benefits under this activity is fairly clear. However, it requires some form of community organization for the management and maintenance of infrastructure, which is not always easy to develop in Madagascar. Income from ecotourism can be high though not steady (tourism seasonality, accessibility issues during the cyclone and *asara* seasons, political instability). The development of tourist activities in fairly preserved and remote areas may generate social problems (such as prostitution, conflicts related to access to land for hotel facilities), as well as environmental problems (such as waste management, access to groundwater in the islands), that must not be overlooked.

FIGURE 7
Local fishers in Madagascar

Source: Photo courtesy of Ambroise Brenier.

CONCLUSIONS

The initial success of the establishment and gazetting of the Ankarea and the Ankivonjy locally managed MPAs shows that the local communities are very responsive to projects aiming at stopping the destruction of marine resources and ecosystems in those areas. Despites low literacy rates, conflicting interests and high dependence on natural resources for their livelihoods, and despite a history of ineffective conservation projects in the region (Baker, Rasoanandrasana and Saula, 2011), it was possible to engage local communities in the enforcement of existing laws and in the development of locally appropriate rules, some reinforcing local taboos, to improve natural resources management. However, considerable efforts are still needed over the long term to build on this initial success and achieve effective management of the Ankarea and the Ankivonjy MPAs, benefitting both biodiversity and livelihoods. Local management and social adaptive capacities need to be built, sustainable long-term financing mechanisms implemented, cross-scale interaction with local, regional and national institutions strengthened, and sustainable livelihoods of coastal communities enhanced and diversified. Ultimately, the outcome will be healthier fish stocks and improved human well-being through increased abundance of fish and invertebrates, and improved food security and livelihoods through increased fish catch and other income-generating opportunities.

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‘The fishermen do it tough, you know’: Oral histories highlight varied impacts on commercial fishers’ livelihoods with the introduction of the Solitary Islands Marine Park, Australia

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“In 1965 we hauled nearly 40 tonne of mullet in one haul.”

Source: Photo courtesy of Ron Fuller, retired commercial fisher, Minnie Water, NSW, Australia.

BACKGROUND

The acceleration of marine resource use globally over the past few centuries has led to a decline in marine ecosystem health and fish stocks (Smith, 2000; Jackson *et al*., 2001; Agardy, 2003; Mullon *et al*., 2005; Worm *et al*., 2006; Halpern *et al*., 2008). This has implications for developing countries in particular, as food security and coastal livelihoods are compromised. For example, the extremely high consumption of fish by many Pacific island countries and territories highlights the importance of fish to the food security of the Pacific (Bell *et al*., 2009). The issue of food security is less prominent in the developed world where protein is accessible from varied animal sources and through imports; however, declining fish stocks in the developed world has a suite of associated social and economic impacts. Fishing livelihoods are often directly affected, but impacts can be further reaching and include disruption of social networks, conflict with other user groups, loss of local services or related businesses, and loss of fishing culture in some fishing villages when an industry closes (Hattam *et al*., 2014; Rees *et al*., 2013).

There are a range of management measures that can be applied to try to address declining fish stocks and ocean ecosystem health, depending on the specific issues and threats (e.g. Lester *et al*., 2009; Selig and Bruno, 2010). Spatial management approaches such as marine protected areas (MPAs) and a range of input- and output-based fisheries management approaches, or combinations of spatial, input and output management (e.g. ecosystem-based management), have been applied globally to facilitate marine conservation and sustainable resource use (Agardy *et al*., 2003; Edgar *et al*., 2014; Jones, 2014). The introduction of management arrangements such as MPAs or fisheries management measures (e.g. licences, gear restrictions, seasonal closures and quota management) can positively (Gell and Roberts, 2003; Malcolm *et al*., 2015) and negatively impact marine users. Negative impacts can include loss of access to a region or resource, increased cost of equipment and a range of additional rules, regulation and administrative burden. Those who derive a living from the sea, such as commercial fishers, are most affected (Pita *et al*., 2011). Impacted fishers may be unable to travel to other fishing grounds due to distance or safety concerns, or, if they do relocate, may displace other users and increase conflict (Pomeroy and Douvere, 2008).

The measure of a negative impact to a commercial fisher is often associated with the loss of income (AgEconPlus Consulting, 2010; NSW MPA, 2010; Eadie and Hoisington, 2011; van de Geer *et al*., 2013). However, Blount and Pitchon (2007) note that many commercial fishers are committed to the fishing industry as a way of life rather than for economic reasons and, therefore, any impacts associated with management actions are not confined to income. Commercial fishers are also challenged by factors external to MPA management, such as competition with imports, cost of fuel, transport logistics, weather and pollution events. Potential benefits of MPAs to commercial fishing include rebuilding of depleted stocks, spillover of larger fish or export of offspring (Roberts *et al*., 2001; Pauly *et al*., 2002; Gell and Roberts, 2003; Murawski *et al*., 2005; Lester *et al*., 2009). Pita *et al*. (2011) noted that in some regions commercial fishers were more accepting of MPAs if they were implemented for the purpose of fisheries management (e.g. through gear-restricted areas) as opposed to conservation (e.g. through exclusion zones). They suggested that the introduction of highly restrictive spatial conservation measures on an already highly regulated fishing industry may have been a contributing factor, although concluded that individual MPAs have different social, cultural, economic and environmental settings, which influences how they impact or will be impacted by the fishing industry.

Improved understanding of the values and attitudes of commercial fishers toward marine protection measures, and the associated impacts on their livelihoods, can inform future planning processes and improve integration of their knowledge into management decisions. The knowledge, observations and interpretations held by

fishers should be considered by planners and managers as they can provide insights into the fishing industry, stock structure, species migrations, spawning aggregations and oceanographic trends (Johannes and Neis, 2007; Fischer *et al*., 2015). Long-term knowledge holders can provide a historical perspective that may not otherwise be available to inform contemporary management. Older, more experienced fishers on the Georgia coast (United States of America) and in Honduras were found to have the most concern for conservation, reflecting sensitivity to continuity of the resource base (Blount and Pitchon, 2007). Fishers have driven conservation measures, including species protection, through their concerns about seriously-depleted stocks (Francis *et al*., 2015). Thompson (1998) notes that oral history interviews can explore historical experiences that are rarely recorded and "offer rich evidence about the subjective meanings of past events". They are also useful when investigating the usage of ocean waters through time where paper records are lacking (Richmond and Kotowicz, 2015).

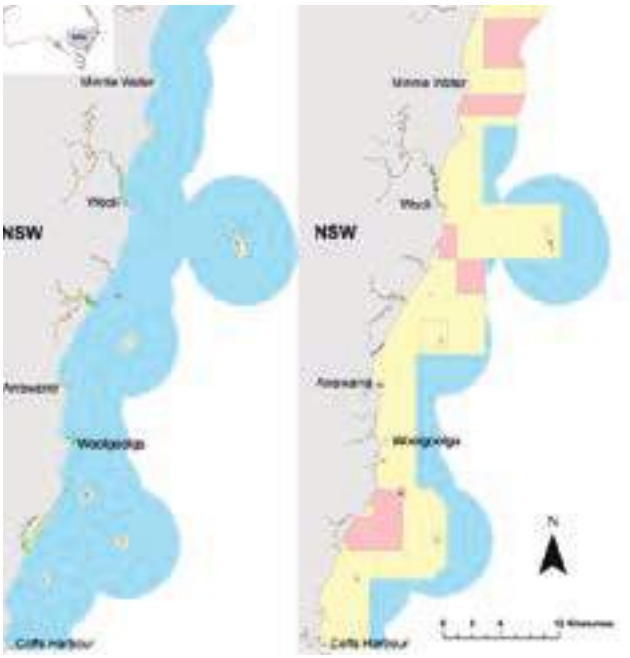
This study focuses on the Solitary Islands Marine Park (SIMP), northern New South Wales (NSW), Australia. SIMP is the oldest marine park in NSW, initially declared in 1991 as a multiple-use marine reserve (Figure 1A) and later declared a marine park in 1998, and rezoned in 2002 (Figure 1B). The term multiple use in NSW marine parks indicates that within the park boundaries various recreational and commercial activities can continue (including fishing), but the location where an activity can occur is dependent upon the placement of management zones within the park. Four zones are applied in NSW marine parks: sanctuary, habitat protection, special purpose and general use.

The former marine reserve included less than 1 percent of the 710 km^2 SIMP in a no-take sanctuary zone (no extractive activities permitted), located mainly around shallow island fringing reefs of the Solitary Islands. Approximately 2 percent was included in a refuge zone (similar to the current habitat protection zone), which prohibited commercial trawling, netting and collecting, located around islands and headlands, and in the upper reaches of estuaries. The former marine reserve was implemented through regulation and an associated zoning plan.

Following a three year management review (1999–2002), a revised zoning plan was introduced. The 2002 zoning plan included 12 percent in sanctuary zone, protecting a broader suite of habitat types throughout the park, and precluded all extractive use. The area of habitat protection zone, which allows for recreational fishing (e.g. line, trap and spearfishing) but prohibits some commercial methods, including prawn trawling, purse seine and set line fishing, was expanded to 54 percent of SIMP. The plan also limited ocean hauling to designated

FIGURE 1

A. 1991 Solitary Islands Marine Reserve zoning plan **B. 2002 Solitary Islands Marine Park zoning plan**



Note: Figure 1A: pink = sanctuary zone; yellow = refuge zone; green = recreation zone; blue = general use zone. Figure 1B: pink = sanctuary zone; yellow = habitat protection zone; blue = general use zone.
Source: Maps reproduced from the Solitary Islands Marine Reserve User Guide and the Solitary Islands Marine Park Zoning Summary and User Guide by the NSW Department of Primary Industries.

beaches and prohibited fish trapping on several mid-shelf reefs, and at all five island fringing reefs.

SIMP supports a diverse suite of commercial and recreational activities, with surfers, swimmers and beach goers the largest user groups (Ryan, 2005). Commercial fishing has a long history in the region, with accounts of large snapper (*Chrysophrys auratus*) catches in 1886 that were dried and sold on passenger steamers (Yeates, 1990). Currently, fishing is centred upon the ocean trap and line (OTL) fishery and the ocean trawl (OT) – prawn fishery. The ocean haul (OH) net fishery and the estuary general (EG) fishery, including crab trapping and hand gathering (for pipis and beach worms) also occur, but to a much lesser extent. In 2010, it was estimated that the commercial fishing sector in the region generated A$12.8 million in gross regional product (0.22 percent of regional gross domestic product) and 155 jobs (NSW MPA, 2010). The majority of commercial fishers access SIMP from the port of Coffs Harbour, one of the safest ports between Sydney and Brisbane; however, a small number launch from beaches (Woolgoolga, Arrawarra and Minnie Water) and rivers (Wooli and Clarence).

The objective of this study was, therefore, to conduct oral history interviews with some of the long-term commercial fishers in the region to gain insights into how they perceived their livelihoods were impacted by the implementation and changing management of SIMP.

METHODS

Semi-structured, in-depth oral history interviews were undertaken with seven local commercial fishers (Table 1) between 2012 and 2013 as part of a broader SIMP oral history project. Oral history interviews enabled participants to reflect on their fishing career in detail and convey actions and feelings associated with events and regulatory change over time. The key theme, relevant to this study, explored in interviews was their view on the establishment and subsequent management of SIMP, and how it affected their livelihood. Among the probing questions asked within this theme, participants were asked to identify one aspect of management they would change if they were given the opportunity or power to do so. This explored whether the participant would seek to rectify impact/s they experienced in future management responses.

TABLE 1
Participant data and fishing status at interview (2012–2013), zoning plan review (2002), and introduction of the first zoning plan (1991)

Participants	Years fishing SIMP and region	Age at interview 2012-2013	Fishing port of origin	Primary fishery	Fishing status 2012	Fishing status 2002	Fishing status 1991
Keith Anderson	56*	82	Coffs Harbour	OTL and OH	Retired	Active	Active
Ron Fuller	30*	72	Minnie Water	OTL and OH	Retired	Retired	Active
Bob Howard	59*	72	Wooli	OTL (fish trap)	Retired	Active**	Active
Barbara Knox	39	82	Minnie Water	OTL and EG (hand gather beach worms)	Retired	Retired	Active
Alan Robinson	28	59	Coffs Harbour	OTL (fish and lobster trap)	Active	Active	Active
Rob Toyer	45*	67	Clarence	OT (prawn)	Semi-retired	Active	Active
Darcy Wright	17	72	Arrawarra	OTL (line)	Retired	Active**	Active

Notes: *Some 5–10 years were spent out of the fishing industry either in Viet Nam or working in sawmills or other occupations. **Retired in 2002 following the zoning plan review.
Source: Oral history interviews, Solitary Islands Marine Park, NSW Australia, undertaken by Nicola Johnstone and Brett Vercoe.

Participants were selected based on: the length of time they had spent in the local fishing industry; their primary fishing method (to include various forms); and the fishing port of origin (to represent the full extent of SIMP). Interviews were recorded on video and hand-held voice recorder and then transcribed verbatim. To ensure accuracy in reporting, participants were requested to check their transcript and video.

The epistemological approach guiding this qualitative research is interpretive, to explore participants experiences as well as motivations and actions. The analysis of qualitative data is often a search for general statements about relationships and underlying themes (Strauss and Corbin, 1997), and, therefore, the data was coded into nodes and subnodes, using Nvivo 10, to identify key relationships and themes. Key themes coded from the transcripts in an iterative process were: impacts of the MPA (positive and negative); other impacts (regulatory and external); and management (change one thing). A general search for references to livelihoods and fishery (e.g. OTL, OT, OH or EG) was undertaken and attributed to each participant. The value of commercial fishing was explored as a lifestyle in the broader oral history study but not expanded upon in this substudy, which focuses on the impact of MPAs on livelihoods.

FINDINGS AND DISCUSSION

Impact of SIMP on livelihoods

During interviews, the seven fishers recollected their commercial fishing experiences over the course of their fishing career. When asked about their views on the management of SIMP over the years, the majority focused on zoning changes that occurred in 2002, rather than the introduction of the initial marine reserve zoning in 1991. Active fishers were involved in the 2002 process through stakeholder meetings, contribution to fishing cooperative submissions and through Bob, who was the commercial fishing representative on the Solitary Islands Marine Park Advisory Committee (a committee which provided advice on marine park management reviews among other things). There is little information on the participation of these fishers in the 1991 process. All seven fishers were active in 1991 but only five active in 2002. The 2002 focus may be due to how we remember events, as memories can be influenced by emotional connection to events as well as time lapsed (Fernbach and Nairn, 2007). As the initial zoning plan included less than 1 percent sanctuary zone, it was less likely to impact upon commercial fishing activities and, therefore, may not have been remembered as an impacting or significant event during interviews. The revised zoning plan, introduced in 2002, increased sanctuary zone to 12 percent, which had implications for all commercial fishers. It also included over half SIMP in habitat protection zone, which prohibited prawn trawling, and also placed limitations on ocean hauling and fish trapping, the primary methods undertaken by most participants.

FIGURE 2
Minnie Water Lagoon boat launch

Source: Photo courtesy of Ron Fuller, retired commercial fisher, Minnie Water, NSW, Australia.

Keith, Barbara and Darcy recollected specific impacts associated with the 2002 rezoning and expressed negative feelings toward the outcome, including the cessation of ocean hauling at night, placement of sanctuary zone on Minnie Water Back Beach and the expansion of sanctuary zones throughout SIMP. Keith noted that ocean haul netting at night was very important to him and his crew, as fish were often spooked by the recreational users during the day. Night fishing also enabled them to avoid confrontation with members of the public who did not support this fishery. When the prohibition on ocean haul netting at night came into place in the 2002 zoning plan, Keith saw no other option but to work outside the park, at night, up until retirement in 2007.

> *I used to work of a night and catch fish and I'd always be there before daylight and [after the rezoning] you couldn't go on the beach till the sun come up… there's never been a fish caught in the park since.* Keith (Pirate) Anderson.

Ocean hauling has continued in SIMP since 2002, although sporadically. Barbara was a skilled commercial beach wormer who had retired prior to 2002 but noted disappointment when Minnie Water Back Beach was included in sanctuary zone. As there are no other commercial hand gatherers in the region, her disappointment was not for the future of that fishery, rather it was associated with her desire to continue to catch worms for recreational purposes and for ongoing access for residents of her small coastal village. The Minnie Water Back Beach sanctuary zone was proposed by recreational fishers from the Wooli/Minnie Water Fishing Club in 2001, as an alternative to other sanctuary zones that had initially been proposed in this part of SIMP. The placement of this sanctuary zone was, therefore, locally driven by recreational fishers. Although most commercial and recreational fishers sought ongoing access to similar areas in SIMP, they provided input into the zoning process independently.

> *It was a good fishing spot, and it was easy to go down there, you could get high tidey worms and all that sort of thing, you know … that really upset me, but I thought, oh well, it's just the way things go … Everything doesn't go our way I'm afraid, and it's got to be looked after.* Barbara Knox

FIGURE 3
Barbara Knox beach worming

Source: Photo courtesy of Barbara Knox, retired commercial fisher, Minnie Water, NSW, Australia.

Darcy, an active commercial line fisher who targeted sharks, expressed surprise at the extent of the change to zoning and saw no future for him under the revised arrangements.

> *One of the final meetings at the co-op (Coffs Harbour Fishermans Cooperative) they had a big glossy map out, you know, and we all looked at it, and they got all their squares (sanctuary zones) on it and I said "Holy shit, Jesus Christ" … so I had a bit of bump the gums there and then, we all had a bit of a say you know … anyhow it got to me and I said to him, I said "I've got three options: I stay home and go broke; I go to sea and fish under new regulations and go broke; or I'm going to sea with a balaclava on and I'm not going broke".* Darcy Wright

A benefit of the revised zoning was mentioned by fishers whereby a buy-out package compensated affected fishers, with A$4 million distributed amongst 26 fishers. However, upon leaving the industry, it was noted by Darcy that a tear was shed at the loss of his lifestyle. For another fisher (not interviewed), it was observed by his mates, and recalled during interview, that the loss was too great, "he watched the boys go fishing week after week, succumbed to cabin fever, missed the lifestyle, and bought back into the industry months later".

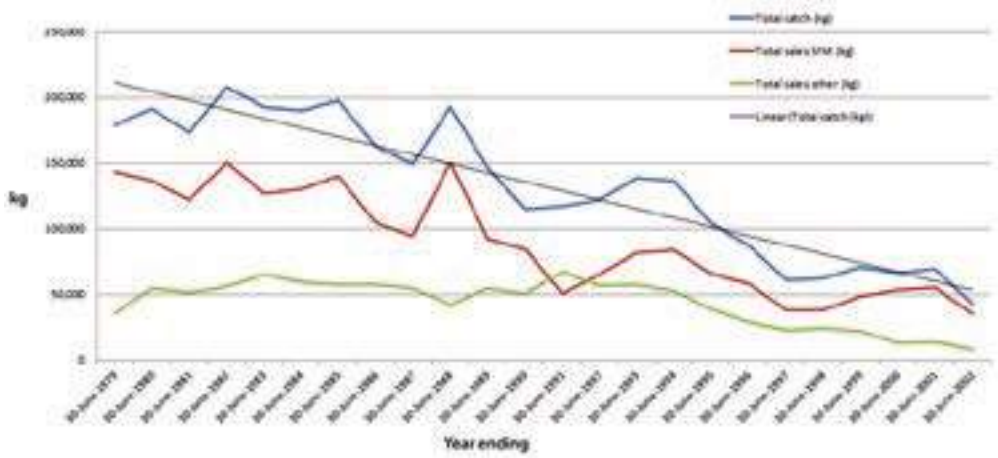
The other commercial fishers Bob, Rob, Alan and Ron suggest they were not greatly impacted when the zoning plans were introduced or reviewed, but rather, reflecting on their observations and experiences, acknowledged the need for some protective measures in SIMP. Rob recalled the introduction of the initial marine reserve in 1991 and noted fishers' collective perspectives in the Clarence region (primarily prawn trawlers) and his feelings associated with the zoning outcome and future of the industry.

> *When the marine park was first mooted there was a lot of resistance in the fishing industry, you know, because the fishermen didn't know what to expect. I think compromise was pretty well achieved when the park first went into place, and from my point of view we got just about everything we asked for. It's what we are looking at now, down the barrel, at the increase in the world population, the increasing use of arable agricultural land, housing land, the continuing loss of water, which is not an infinite resource as everybody likes to believe, and the necessity of us to really effectively produce food. If that food is going to come from the sea, not only do we have to be able to take it from the sea, but in doing that, we've got to ensure sustainability.* Rob Toyer

On reflection, Rob suggested that compromise was the key. The fishers went into the MPA design and implementation process prepared to negotiate ongoing access to some grounds, while accepting the closure of others (including nursery areas). As a result, Rob has observed improved prawn trawl catches adjacent to the closed area and suggests zoning contributed to this. Bob spent close to 60 years fishing in the region, was Chairperson of the Wooli Fisherman's Cooperative for 14 years, and on various government committees (fisheries and marine parks) representing commercial fishers for over 20 years. Bob is adamant that commercial fishing is very much a livelihood, and not a lifestyle, and justified that by saying "you never see a happy fisherman, Nicola!". Bob offered insights into a changing seascape, was particularly concerned about reduced catches at the Wooli Fisherman's Cooperative over 20 years, as shown by their total catch and total sales data by year (Figure 4), and offered strong feelings on the protective measures introduced.

> *About the best thing that happened to our part of the coast was the marine park. A bit late. Still got some hassles about, not how it's managed, about how some of these zones are put into place and why they are put into place. I think it could be modified and made better. Mainly for the benefit of the actual environment ... I think if you have regulations, like keeping the trawlers out and having only [fish] traps with escape panels in, and things like that, we can sort of have our cake and eat it too. I have noticed over the years the fish stocks decline. It's harder to catch the product, 'cause the product is not there, the reason the product is not there is because we overexploit our oceans.* Bob Howard

FIGURE 4
Total catch statistics



Notes: Total sales SFM = total weight (kg) of fish sold through the Sydney Fish Markets (the largest fish market in NSW). Linear = trend of total catch.
Source: Bob Howard, Chairman of the Wooli Fisherman's Cooperative, from the Cooperative's catch and sales data and reproduced by the NSW Department of Primary Industries.

Ron, based in the small coastal community of Minnie Water recalled his career very fondly, and valued most the comradery and mateship formed with other fishers in the region. He experienced the introduction of a range of management measures, but was retired at the time of the 2002 zoning review. Nevertheless, Ron noted general support for SIMP over the years, but did reiterate Barbara's concerns with the closure of beaches to fishing when placed in sanctuary.

> *I don't think they have hurt us much here with the marine parks, I think they haven't taken too much. But I do think that the beach [Minnie Water Back Beach] should be open for worming you know ... no, it [marine park] works alright here, I haven't heard much complaint about it here at all, the way it is at the moment.* Ron Fuller

Alan was the only full-time active fisher at the time of the interview, with close to 30 years experience fishing from the port of Coffs Harbour. He was also active when the initial marine reserve was introduced and during the rezoning in 2002. Alan discussed a range of factors affecting his livelihood (other than SIMP) but not to the detriment of his career at present. He appreciated the need for sustainable management to continue in the industry, but noted caution in potential livelihood impacts into the future.

> *There is not much to say. I mean, marine parks work, I think, and you can't keep taking and taking it [product]. Commercial fishing has been restructured and we've got quotas with lobsters and that now so you can only take so much anyway ... They have got to be policed and controlled but, I mean, we should still be able to have access, not complete shut out, still be able to have access to areas that are so pristine, nice, beautiful.* Alan Robinson

The age and status of fishers (active or retired) at the time of rezoning may have influenced how they perceived impacts associated with regulation changes. Pita *et al.* (2011) suggest that fishers who generally benefit more from the implementation of the MPAs, or that are less affected by them, tend to be more accepting and supportive of them. Those close to retirement, who received a buy-out package or continued in the industry, had fewer negative feelings toward the changes. Alan and Rob, who continued fishing after rezoning, may have anticipated benefits associated with the zoning such as reduced competition with other fishers and increased sustainability. Their understanding of these MPA benefits is likely a contributing factor towards the positive views they expressed towards protected area management on the whole.

When each of the seven fishers were asked the one change with regard to management that they would make, two chose to rectify the specific impact they experienced with the introduction of the 2002 zoning plan: (i) reintroduce ocean haul night fishing; and (ii) remove sanctuary zone from Minnie Water Back Beach. The others offered various suggestions for future consideration: (iii) allow pelagic fishing in any zone; (iv) rotate sanctuary zones over time; (v) put an MPA around Australia and manage it properly; and (vi) review trawling in sensitive locations; or no change.

Other impacts

Participants noted impacts to their livelihoods other than those related to the SIMP regulations. Fisheries management arrangements were raised as an issue for some fishers, as well as varied external factors. Alan noted the cumulative influence of fisheries management requirements and external factors on the deterioration of his experience as a commercial fisher.

> *It's a lifestyle, you know, you don't want to be tied up with rules and regulations and filling in books, and as you get older of course the more you don't like it ...You work some terrible weather at times and then you got the prices fluctuate on you ... you are at the mercy of the buyers in Sydney [Sydney Fish Markets]... mercy of the trucking company ... we don't use as many traps now as we used to either because the price of bait and wire, and you've got to work pretty economically these days.* Alan Robinson

Ron observed the challenges fishers face today as opposed to the good old days when he was active in the industry.

> *The fishermen do it tough, you know ... the fuel is a big thing for these fishermen ... and they are going to bring more imports into the country, they are bringing them in now, you know.* Ron Fuller

Bob shared views on external impacts that affected his livelihood similar to those of Ron and Alan, but also offered an additional insight (real or perceived) into declining fish stocks and the health of local waterways.

FIGURE 5
Joe Fuller, trap and line fisher in Minnie Water, NSW, Australia

Source: Photo courtesy of Ron Fuller, retired commercial fisher, Minnie Water, NSW, Australia.

> *They drained all our commons and waterways and that's where life begins for our fish stocks, and all this urban development, sugar-cane farms along the waterways, they put about seven tonne of super [superphosphate] a year which leaches into the river, and the stuff they use to kill the pests is poison, it gets into the river, and they wonder why fish stocks aren't what they used to be.* Bob Howard

Interviews indicate that these commercial fishers have real concern for the environment, as their livelihoods depend on its productivity. Bob suggested that commercial fishers have the most to lose if stocks decline, and are, therefore, the ones that are most likely to support sensible protection measures to address threats. Blount and Pitchon (2007) note that the willingness of the fishers to comply with MPAs is a central factor to their success and if equity is not included in the MPA design, fishers are more likely to resist compliance. Several fishers noted declining stocks and offered general support for SIMP. Their long-term observations in the fishing industry have influenced their views on management needs. The positive associations these fishers recall with regard to SIMP suggest that a balance of conservation and use was achieved through zoning, but acknowledges there were some impacts to livelihoods as a result, particularly in 2002. A range of other impacts, regulatory or external, add to the challenges faced as a commercial fisher in a highly regulated industry. Importantly, through oral history interviews, this study not only highlights impacts to fishing livelihoods, but it also revealed observations of a changing seascape, physically, socially and economically, that may not otherwise be documented. The fishers' collective knowledge forms a valuable narrative that will improve integration of social and economic factors into future protected area management. Fischer *et al.* (2015) state that it is important that MPA design and implementation processes provide a space for knowledge exchange, encourage active participation, foster empowerment and create a platform where knowledge is co-produced to minimize differences in power.

CONCLUSION

Oral history interviews with long-term SIMP commercial fishers have provided insights into the importance of fishing as a livelihood. They relay impacts associated with the introduction of management arrangements; spatial (MPA) and input/output-based (fisheries management). Commercial fishing was, and continues to be, an occupation that is very demanding and physical, and generally not considered lucrative

for the majority of fishers. Interviews indicate that for some fishers it was more the lifestyle than the livelihood that was the greatest motivator, and, as one fisher recalled, the loss of the lifestyle, not the livelihood, was the driver for a colleague to buy back into the industry despite a more restrictive management plan. The increased regulatory framework introduced in SIMP, in combination with fisheries management and external factors, has had an impact on fishers livelihoods. However, general support for SIMP was noted by several fishers interviewed. Some fishers modified operations in response to increased regulation and acknowledged the reason for such constraints, while some fished elsewhere or left the industry with mixed emotions. Monetary compensation received, and increased age of the fishers at the time of implementation most likely influenced a more positive association with the zoning plan when introduced in 2002. This study shows that historical perspectives are useful to better understand the impacts of an MPA on commercial fishers' livelihoods; and highlights that fishers' knowledge is important, and best considered early and cooperatively, in any future MPA design or rezoning process. Further work is required to understand the lifestyle values that fishers associate with SIMP, as it was more than just a livelihood for some; and to further investigate the physical, social and economic changes observed over time in SIMP and the region more broadly.

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Impacts of marine protected areas on livelihoods and food security of the Bajau as an indigenous migratory people in maritime Southeast Asia

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INTRODUCTION

Over the last decade, the global conservation agenda has increasingly recognized mobility as an important livelihood and management strategy for indigenous people, acknowledging the need to secure their ongoing access to natural resources within territorial waters and transboundary regions. A growing policy framework exists to support equity, indigenous rights, access to natural resources, participation in management of conservation areas and compensation resulting from loss of access to resources. The rights of indigenous peoples, including sea nomadic or migratory peoples,[1] were recognized in 1989 under Article 4 of the International Labour Organization Convention. Various resolutions, recommendations, declarations and principles, formulated at conservation meetings, including the Convention on Biological Diversity and the World Parks Congress (WPC), have acknowledged the need to secure ongoing access for indigenous mobile and nomadic peoples to natural

[1] The authors refer to indigenous migratory peoples as a subset of indigenous peoples whose livelihoods depend on extensive common property use of natural resources over an area. This includes those who use mobility of some form as a livelihood and management strategy. It includes sea nomads (i.e. historically foragers who lived on boats or in stilt houses, maintaining mobile and migratory livelihood strategies over large geographic areas.), nomadic pastoralists, transhumant herders, shifting agriculturalists and hunter-gatherers.

resources within local and transboundary protected areas in order to enable them to continue to hunt, gather and fish for both subsistence and income-generating purposes.[2]

Migration is recognized as one of three broad livelihood strategies of rural peoples (Scoones, 1998). In the context of small-scale fisheries, the term "migration" is used in the literature to refer to the nomadic-like characteristics of fishing populations who support their livelihoods through pursuing opportunities based on spatial and temporal movements of fish populations along with other socio-economic drivers (Aburto, Thiel and Stotz, 2009; Cripps, 2009; Njock and Westlund, 2010; Jorion, 1988). Migration can take a number of forms as voluntary, permanent or temporary (Crona and Rosendo, 2011). Seasonal migration strategies from home or ancestral villages can be classified into two main categories: movement to "satellite bases" or seasonal encampments, which can involve spending short stays (weeks or a few months) in other recurrently visited locations or villages in a hut on a beach to fish or access nearby fishing grounds, or migration to another place as a semi-permanent move, although after a period of time – years or decades – one may be back to one's ancestral village (Jorion, 1988). People can also alternate between extended periods of time living on boats and periods of residence in houses in a single or more locations.

While the global agenda is striving to accommodate this form of livelihood strategy, it is simultaneously misrepresented in conservation literature (e.g. Hoegh-Guldberg *et al*., 2012). Stereotypes of mobile peoples as unsettled, with no home base or fixed address, and as variously uncivilized, backward or alien (Lowe, 2006) fail to recognize the complex and dynamic connections linking migratory people to particular locations, settlements and trading routes through kinship networks, patron-client ties and economic activity (Lowe, 2006; Gaynor, 2005; Stacey, 2007).

Area-focused conservation strategies, such as marine protected areas (MPAs), often conflict with cultural and livelihood practices of migratory or semi-nomadic maritime indigenous groups, with implications for food security within such communities. In this paper, these issues are examined in the context of maritime Southeast Asia. This region's high marine floral and faunal biodiversity (Veron *et al*., 2009) is acknowledged in the implementation of the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF), a multilateral partnership launched in 2009 involving Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands and Timor Leste, and focusing on six key shared issues, including food security and marine conservation. In this paper, case studies from Indonesia and Malaysia explore the connections between conservation, food access and food availability experienced by the Bajau, an indigenous mobile population numbering approximately 1.1 million people (Mead and Lee, 2007) in Southeast Asia (Figure 1).

The dependence of the Bajau on marine resources for food, housing and fuel reflects not only their historic role as seafaring traders, specializing in high-value products such as beche-de-mer, but also their maritime lifestyles, which, up until recently, involved families living entirely at sea and engaging with land-based communities primarily for trading purposes (Stacey, 2007), although with more recent sedentarization many Bajau communities now orient more to reef fish and other species closer to shore. Reef finfish, small pelagics, invertebrates, inshore and mangrove species, providing important micronutrients, protein and other minerals, play an important role in the nutritional health of these populations. Previous studies estimated that Bajau

[2] For example: 2002, Pre-WPC Dana Declaration on Mobile Peoples and Conservation; 2003, WPC Recommendation 27 Mobile Indigenous Peoples and Conservation in the Durban Action Plan endorsed the Dana Declaration; 2005, World Conservation Congress (WCC, Bangkok) Resolution 3.018 on Mobile people and conservation; 2008, WCC (Barcelona) Resolution 4.053 Mobile indigenous peoples and biodiversity conservation; 2012, WCC Resolution 076 Transboundary cooperation around and between large MPAS, which takes into account mobile or migratory populations and to follow the ocean currents (IUCN, 2012:108); 2013, Asia Parks Congress Asia Protected Areas Charter Statement for WPC 2014; and 2013, Asia Parks Congress.

FIGURE 1
Locations of the Bajau case study sites in Indonesia and Malaysia

Source: Observatoire-PNBA, 2015.

fishers are reported to collect over 300 marine species for food, medicine or trading purposes (May, 2005). While post-colonial governments' efforts to sedentarize the Bajau and other maritime communities in Southeast Asia have been generally effective, contemporary Bajau settlements are commonly built on stilts extending over the reef flats, indicating their ongoing close association with the maritime world and lack of ownership or usage rights over terrestrial resources in Southeast Asia.

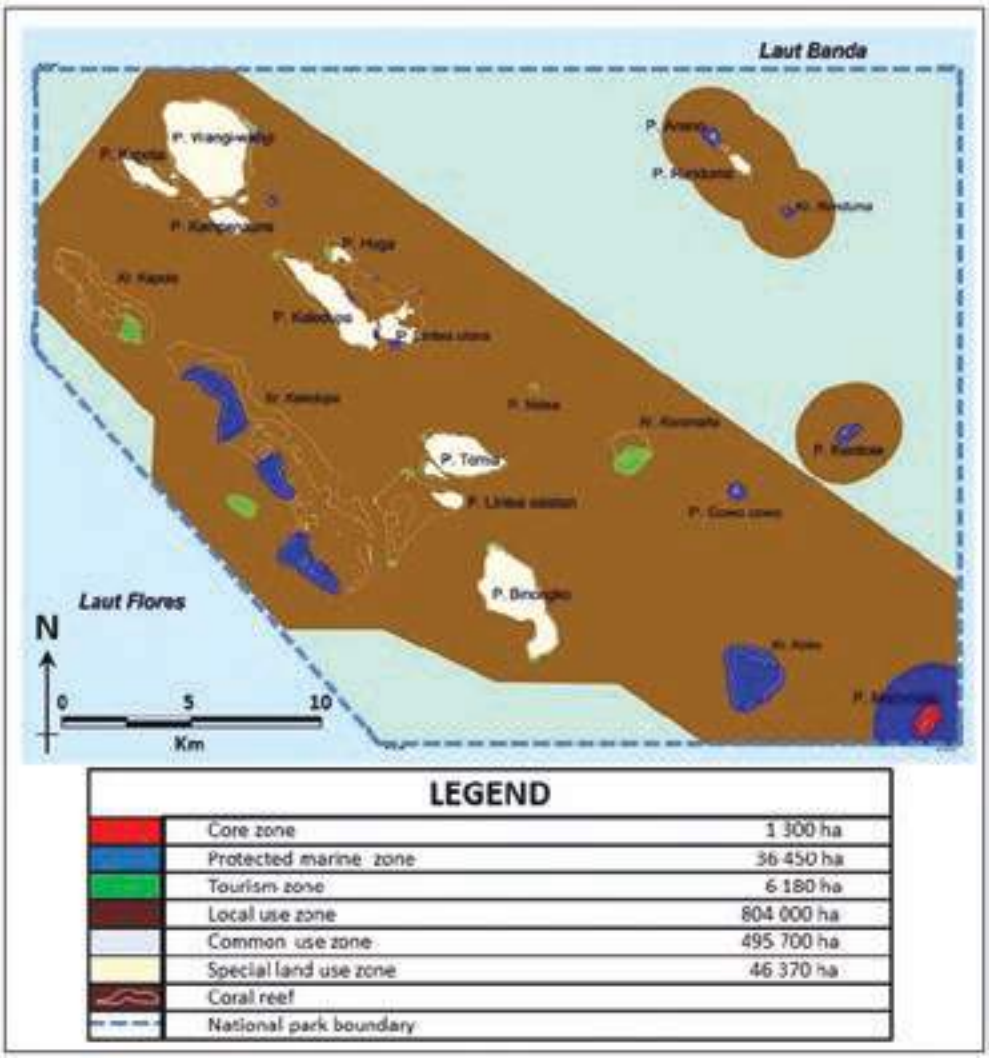
In the region's small-scale fisheries, men and women assume complementary roles as part of their coastal livelihoods (Weeratunge, Snyder and Choo, 2010). These roles are changing for the Bajau in response to many external drivers (Gaynor, 2005). Women's diverse roles and their significant contribution to household food and livelihood security, and to local and regional economies through their participation in fisheries and aquaculture, include participation along the value chain as producers (e.g. reef gleaners, divers, inshore fishers), processors (e.g. in processing plants, drying fish) and local market vendors (Fitriana and Stacey, 2012). Moreover, they mediate access to food in households and, thus, the health and well-being of families, in their role as fishers and decision-makers on household food expenditure, as well as in their child-rearing roles.

CASE STUDY 1: THE BAJAU OF WAKATOBI NATIONAL PARK IN SOUTHEAST SULAWESI, INDONESIA

Designated in 1996 and covering 13 900 km^2, Wakatobi National Park (WNP) in eastern Indonesia encompasses the four main islands of Wangi-wangi, Kaledupa, Tomia, and Binongko, with a total population of around 100 000 people. The park's zonation, which was revised in 2008, is depicted in Figure 2. All fishing activity is prohibited within core zones (shaded red), marine protection zones (blue) and tourism zones (green), which collectively cover 3.4 percent of the total marine area of the park. Predominantly located on fringing reefs around the islands of Hoga, Kaledupa and Tomia, most of these no-fishing zones are relatively small, being less than 1–2 km^2 in extent. The largest no-fishing zone surrounds the remote atoll of Pulau Moromaho

in the far southeast of the marine park (Figure 2), with other no-fishing zones on the subtidal reefs of Karang Kaledupa in the west.

FIGURE 2
Zonation of Wakatobi National Park, Indonesia



Source: Amended from Peta Zonasi Taman Nasional WAKATOBI, 2010.

The six Bajau communities, comprising approximately 7 000 people, are spread across four islands, with the largest on Wangi-wangi. The three-month survey of Bajau fishing activity conducted by the authors in 2004, recording catch, fishing location and techniques used in over 300 fishing trips, based upon the Sampela Bajau community on Kaledupa, revealed a high number of species targeted by Bajau fishers. Eleven families of fish accounted for 90 percent of the total catch, with emperor fish (Lethrinidae) the main target (28 percent of the catch), along with grouper (Serranidae), rabbitfish (Siganidae) and snapper (Lutjanidae), each representing around 8 percent of the catch. Fishing effort was almost exclusively concentrated over the nearshore reef and seagrass habitats, with less than 10 percent of fishing time spent beyond the reef. The catch composition and spatio-temporal distribution of effort recorded in 2003 is reflected in more recent surveys conducted in this region (Unsworth *et al*., 2014).

The Bajau in WNP addressed food insecurity associated with the inherent unpredictability of fishing through the practice of food sharing, drawing upon and

FIGURE 3 AND 4
Bajau families trading the day's catch and View of Bajau village at high tide, Sampela village, Wakatobi, Indonesia

Source: Photos courtesy of Julian Clifton.

reinforcing interpersonal linkages through reciprocal distribution of daily fish catches between family members and fishing crews (cf. Sather, 1997). As changing fishing technology (e.g. natural fibre nets being replaced by nylon nets which require less ongoing maintenance) has resulted in fishing becoming less reliant on collective effort, food sharing has become less prevalent, although still practiced within extended families. Furthermore, the diversification of income-generating activities into areas including seaweed cultivation, government development projects and small businesses has resulted in growing heterogeneity with respect to household dependence on fishing. Members of a minority of better-off households are increasingly employed in the private or state sector, which has been boosted by reorganization of local government, while a majority of poorer households maintain strong engagement in everyday fishing, generating divided micro economies-of-scale within communities (Steenbergen, 2006). The divisions resulting from these internal differences will determine how individuals and families respond and cope with any potential shocks affecting their food security (e.g. health impediments or fishery collapse). However, a combination of gear limitations and cultural traditions exacerbate the exposure of Bajau fishers to food insecurity. Increasing sedentarization of Bajau communities (Clifton, 2015) has subjected nearshore reefs and seagrass meadows, particularly those near Bajau settlements, to higher fishing pressure and, potentially, overuse. Most fishing takes place using nets and lines deployed from small dugout canoes with a limited range, with access to offshore atolls and reefs only possible for six months each year due to regional wind conditions. However, all Bajau communities experience constraints on physical access to alternative terrestrial food sources, as very few Bajau individuals hold land ownership rights. The perceived decline in catches elicited in repeated surveys of fishers' opinions conducted by the authors over the past 15 years echoes studies of target species, such as octopus and bêche-de-mer, indicating an increased strain on food security. From a cultural perspective, however, the historical mobility of Bajau fishers entails a lack of incentive to initiate community-based fisheries management regulations in response to declining catches (Satria and Masuda, 2004), as fishers simply move to new moorings and fishing grounds. Bajau perceptions of causality, including a persistent belief in spirits' control over individual fishing, decoupling human actions taken in the present from future impacts, exacerbate such decline (Clifton and Majors, 2012).

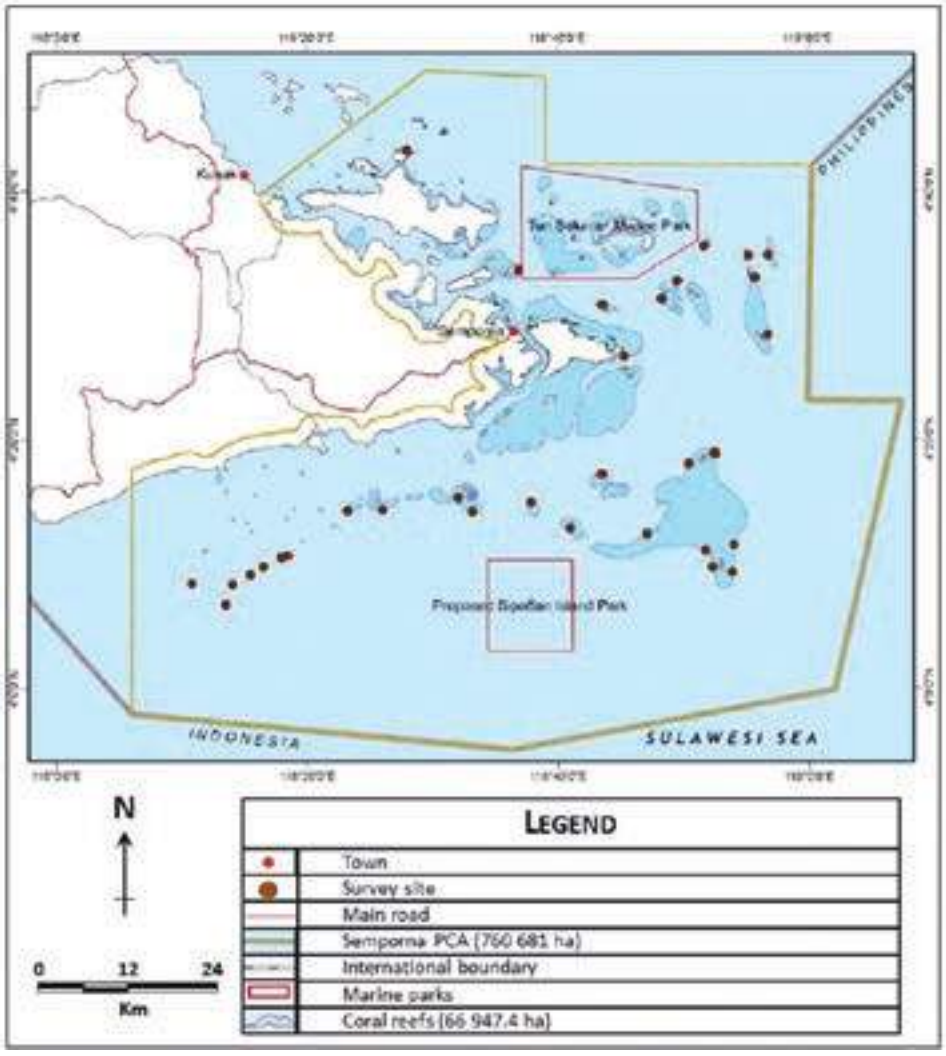
The extremely small size of the no-take zones (NTZs) in WNP raises concerns, as reserves of this size may offer little protection to mobile demersal species, such as

those relied on by the Bajau (Bornt *et al*., in press). The level of NTZ enforcement depends upon proximity to tourist activity in WNP, paralleling other MPAs in Indonesia where tourist operators play significant roles in supporting conservation (Steenbergen, 2013). Heavy policing of NTZs occurs particularly around the island of Tomia through support by the local tourist operator, while inadequate state funding mechanisms constrain enforcement elsewhere (Clifton, 2013). The overall effect of these NTZs may simply be to transfer fishing effort to neighbouring areas, leading to stress on economic and physical access to food among the Bajau. Designating NTZs in suboptimal locations is, therefore, unlikely to generate any benefits associated with food security for the Bajau. This is exacerbated by the exclusion of Bajau resource use practices from management decision-making processes.

CASE STUDY 2: THE BAJAU LAUT OF TUN SAKARAN MARINE PARK, EASTERN SABAH, MALAYSIA

Tun Sakaran Marine Park (TSMP) was gazetted in 2004 and covers an area of approximately 350 km² in the southeastern portion of Darvel Bay, eastern Sabah,

FIGURE 5
Tun Sakaran Marine Park within the Semporna Priority Conservation Area in Southeastern Sabah



Source: www.naturalis.nl/en/news/zeeteam-expeditie/semporna-biodiversity-hotspot, last visited 28-06-16. WWF-Malaysia, production date: October 2009.

Malaysia (Figure 5). TSMP forms part of the Semporna Priority Conservation Area (SPCA) within the Sulu Sulawesi Marine Ecoregion, which constitutes a priority seascape in the CTI-CFF.

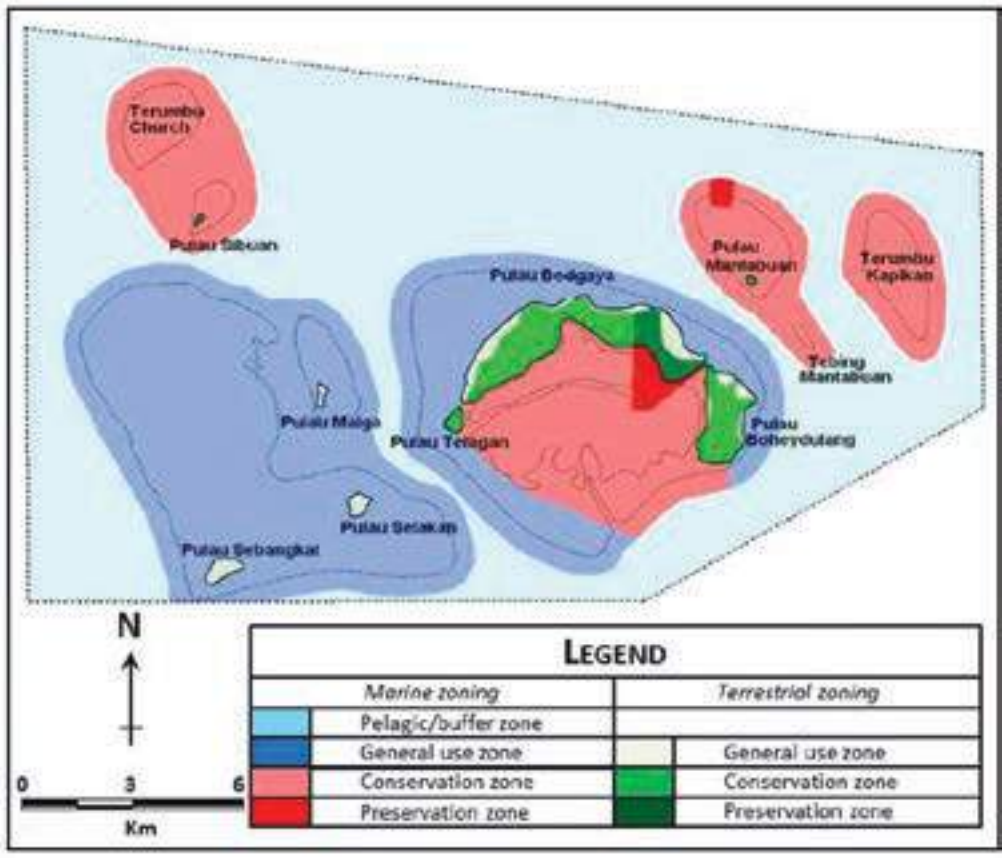
The population survey conducted in 2001 for the draft management plan indicated that the park included 2 061 residents, 25 percent of whom were Bajau Tempatan ("emplaced" Bajau, i.e. those who have long been sedentarized in the region) occupying the larger islands. They practice fishing, cultivation (e.g. fruit trees, including coconuts) and some seaweed cultivation, and are Malaysian citizens who have settled in the islands for some generations. Approximately 18 percent of the population were Bajau Laut ("sea" Bajau), who are now largely semi-sedentary, living either offshore of the main islands – the volcanic remnants Boheydulang, Bodgaya and Tetagen and the raised limestone platforms Selakan and Sebangkat – or in huts on the beaches of the sand cays – Maiga, Sibuan and Mantabuan – and using houseboats for regular travel. Almost all the Bajau Laut in the park are stateless, being neither Malaysian nor Philippine citizens. The remainder of the population are Suluk, originally from the Sulu Archipelago, where they are known as Tausug, who mainly practice seaweed cultivation in the general use zone north of Sebangkat Island.

A recent survey indicated that over 90 percent of Bajau Laut respondents cited reef fish as a "very important" or "fairly important" component of their diet, with octopus, sea cucumber, snails, claims, horseshoe crab, mangrove crab and sea urchins ranked as less important (Wood and Habibah, 2014), both for subsistence and trade (Sather, 1997: 109). However, all the reefs extending from the islands and sand cays in TSMP were declared either "conservation zones" or "preservation (i.e. fish spawning) zones" in 2009 (Figure 6).

Both of these zones preclude all resource consumption, thereby rendering them equivalent to NTZs and effectively barring the Bajau Laut residing within the park from harvesting the areas providing the main source of their food. Bajau Laut fishers have responded by fishing further afield, extending to the pelagic zones at the edges of the park and into the Sulu Sea beyond; 44 percent of the Bajau Laut in the SPCA survey report going further afield to catch fish (Wood and Habibah, 2014). This displacement of primary fishing area has also meant a change in primary technique, with almost exclusive reliance on hook and line fishing, rather than the spear fishing used in shallow waters by the Bajau elsewhere (cf. Sather, 1997: 105–116; BBC One, 2014). Much of the shallow water above seagrass in the park has been allotted to seaweed cultivation, clustered in what are now general use zones of the park (Figure 4). Because of past experiences of seaweed lines being fouled, seaweed cultivators, predominantly the Suluk, threaten any fishers they find in the vicinity of their seaweed lines, thus effectively barring the Bajau Laut and others from fishing there.

However, the park's zonation has exerted an even greater impact on Bajau Laut women, who have traditionally contributed to household subsistence and market production by gathering various types of shellfish and other marine species found in mudflats and intertidal flats, as well as from shallow water in reef areas. With these areas now encompassed within the NTZs, women's ability to sustain these contributions has eroded. Some Bajau Laut women have reoriented themselves to other activities, including basket, mat and other handicraft production, but the limited amount of marine tourism in the park has meant a limited market for such production; hence they earn little cash to exchange for food. Cash is essential for the Bajau Laut in order to purchase non-marine foodstuffs needed for their diet, especially the staple cassava flour. Their inability to grow any food on the islands of the park, to which they have no land rights, coupled with the diminution of opportunities to access cash due to restrictions on reef fishing and collecting has decreased their access to essential components of their diet, thus increasing their food insecurity.

FIGURE 6
Zonation of Tun Sakaran Marine Park, Malaysia



Source: Amended from Tun Sakaran MNP information pamphlet [undated], accessed in 2014.

The other outlet for women, and to an extent men as well, is seaweed cultivation. However, a major impediment to pursuing this option is the requirement of Malaysian citizenship to gain a license to be allotted a plot in order to cultivate seaweed. As a result, many Bajau Laut have only been able to gain rights to glean what has dropped to the seabed below from the seaweed lines during harvesting. Bajau Laut women have turned to drying this gleaned seaweed for sale, though only on a very small scale. In addition, the increasing incidence of ice-ice disease (Uyenco, Saniel and Jacinto, 1981) accompanying intensification of seaweed cultivation in the region, in part as a result of increasing surface sea temperature, exacerbated by climate change, has led to declines in the harvests and of the proportion of the highest quality of seaweed, reducing the potential of this activity as an alternative livelihood. This is true even for those who have managed to establish their own seaweed lines, due to intentionally lax enforcement of licensing restrictions by Sabah Parks in compassionate recognition of the difficulties faced by the stateless Bajau Laut and Suluk, and with the hope of fostering better compliance with fishing restrictions.

The limitations imposed upon Bajau Laut livelihoods by the conservation initiatives in the eastern Sabah region must also be viewed in the context of the wider political restrictions imposed on them as stateless inhabitants of Sabah. In the wake of the "invasion" of eastern Sabah in February 2013 (Franco, 2013) by followers of a claimant to the Sulu sultanship seeking to enforce claims on this region, much of eastern Sabah has been designated the Eastern Sabah Security Zone (ESSZONE) by the Malaysian Prime Minister. As they are not Malaysian citizens, the Bajau Laut have been targeted within this security regime as potential facilitators of foreign incursions, given their knowledge of the Sulu Sea and the movements of security forces. Not only have the

Bajau Laut rounded up in and around Semporna been subject to deportation, but those continuing to reside in the area have been severely restricted in their fishing activities by the imposition of a dusk-to-dawn maritime curfew. The number of illegal Bajau Laut migrants to Berau and other parts of East and North Kalimantan that have long harboured Bajau Laut populations (Pauwellussen, 2015) began to increase shortly after the curfew was imposed, indicating that its effect on subsistence pursuits (e.g. nocturnal fishing) was forcing the Bajau Laut to flee to areas of (imagined) less restriction.

FIGURE 7 AND 8

Bajau Laut woman checking for shellfish and other food sources in shallow water off Selakan Island in a General Use Zone of Tun Sakaran Marine Park and Bajau Laut fishing in the pelagic zone of Tun Sakaran Marine Park, the last area open to them for fishing within the park

Source: Photos courtesy of Greg Acciaioli.

However, the subsequent deportation of many of the Bajau Laut apprehended by Indonesian security forces back across the border to Sabah has curtailed this option.

DISCUSSION

The preceding case studies have highlighted the presence of ongoing chronic stresses that, coupled with more recent developments, destabilize various aspects of food security for the Bajau. The continuing process of sedentarization, with its inevitable concentration of fishing effort, following from impediments to the former wider spatial distribution of fishing pressure enabled through nomadic fishing strategies, represents a potential driver of food insecurity and consequent resource decline, although there are insufficient data to conclusively demonstrate the significance of this in both case study areas. Climate change will exacerbate issues of food availability through altering marine environmental conditions, particularly water temperature, with the potential loss of coral and seagrass habitats and increasing incidence of diseases attacking seaweed plots. However, the timing and magnitude of these stresses remain uncertain. Set against this backdrop are more localized and, it could be argued, more significant drivers of food insecurity reflecting government policy decisions and priorities. In both case studies, aspects of marine conservation policy directly impact physical and economic access to food for the Bajau, which, coupled with broader policy decisions relating to marine security, are increasingly restricting the capacity of Bajau communities to adapt to these stresses.

Definitions of food accessibility and availability in the context of food security, when framed along lines of food production, distribution, pricing and markets (Cruz-Trinidad *et al*., 2014), fall short in capturing livelihood systems of the Bajau, where food security hinges upon peoples' capacity to access natural food stocks through

nomadic, marine territory-based fishing strategies accounting for variable productivity and weather conditions, as among mobile land-based hunter-gatherer cultures. In the context of the Bajau, a more appropriate conceptualization of food accessibility would, therefore, include the physical capacity to harvest fish or other marine resources (i.e. with health and capacity to access transport and fishing technology), natural opportunity (i.e. sea conditions) and the political opportunity (i.e. policies, regulations and laws governing access and fishing practices). Similarly, food availability for the Bajau, as primary collectors in a supply chain, would highlight equally issues of ecosystem health and market distribution capacity, whereas secondary actors along the supply chain would relate more immediately to the latter. We explore these dimensions of food security in more detail below.

Food accessibility

The drive to meet recent international targets relating to MPAs, including the extent of NTZs, serves to further prioritize biological criteria over those relating to local communities' needs in marine planning activities. Consequently, the designation of NTZs may often further undermine food security among the Bajau, especially given the focus upon reef areas, a preferred Bajau focus for fishing and other food gathering. The extent to which food security among fishing communities can be enhanced by larval export and spillover from NTZs depends to a large extent on the biological productivity of the site, its size and the level of enforcement as well as on the level of exploitation outside the area (Hilborn *et al*., 2004) When NTZs are located either in known spawning and aggregation sites, areas of tourist presence or remote atolls and reefs, rather than being based on detailed knowledge of fish behaviour within the entire marine park, the exclusion of fishing from these sites may be justified on biological grounds, but clearly has implications for food supply stability, particularly when opportunities to travel to alternative fishing grounds are limited.

The establishment of NTZs is usually predicated on biological criteria reflecting marine ecosystem biodiversity, after which zonation proposals are typically amended through consultative and decision-making processes with local stakeholders. Such processes have generally excluded Bajau communities from marine planning and conservation across Southeast Asia (Clifton, 2003; Foale *et al*., 2013), reflecting their marginalized status and peripheral geographical distribution (Acciaioli, 2001) and the linking of the Bajau with destructive or illegal fishing practices (Pet-Soede and Erdmann, 1998). The socio-economic divides emerging within Bajau communities in WNP, resulting from increased incorporation of some sections of the Bajau population into private and government initiatives, produce disproportionate representation of economically and politically privileged households over the poorer, more fishing-active and most fishery-dependent households. Similar divides are evident in TSMP between the Bajau Laut and the Bajau Tempatan; although the former are most dependent on the fishery, as stateless inhabitants they are ineligible to participate in decision-making processes. Since consultative processes build on actors who are available and willing to contribute, underrepresented "shadow" groups remain excluded, even though these very groups show a higher direct livelihood dependence on fishing activity. While access to prime fishing grounds is imperative for the most fishery-dependent households, their lack of direct involvement in discussions around NTZ allocations means contestation over claims to access (and related non-compliance) will necessarily continue.

The broader sedentarizing policies in Indonesia and Malaysia mean Bajau livelihoods are increasingly becoming "place based". Moving between fishing grounds that are increasingly defined under particular jurisdictional control means former migratory livelihood strategies are no longer viable and often not even possible. This is echoed further in the way conservation management occurs, whereby community involvement

measures see the recruitment of the Bajau into roles that associate them with a defined area.

In TSMP, the impacts of the park are heightened in relation to women. Given the role of women in provision of household food security through their reliance on accessing areas inside the park for nutritious food sources such as shellfish, the restrictions imposed by the park have a flow-on effect, especially in the context of limited livelihood opportunities now available. It has been shown in other coastal contexts (e.g. Beaumier and Ford, 2010) that in times of food insecurity, it is women who often forgo meals when food supplies are limited. Further, a reduction in nutritionally important marine foods available to the household will have consequences for children's health.

Food availability

Besides fulfilling nutritional subsistence needs through their fishing, Bajau fishing households depend on market sales of fish and other marine resources for income, which they require to purchase other complementary foodstuffs needed for nutritional security. Land-based households, on the other hand, depend on the supply of these products at markets to be able to buy and consume fish. Bajau fishing activities thus constitute the base of local supply chains which connect inland non-fishing households with the food source. The local distribution of fish that upholds food security of a wider local population is largely conditioned by the Bajau's ability to supply fish. The Bajau thus play a significant role in maintaining food availability for households that do not engage in fishing. Placing barriers to their fishing capacity may, therefore, have cascade effects not only for food security for a larger population, but also for conservation efforts. Declines in fish supply or a rise in fish price may drive increased fishing activity by land-based groups. Such fishing activity would likely concentrate around inshore shallow coastal zones given their general inexperience in fishing. As a result, fish trapping and gleaning in the tidal zone, as well as targeting of juvenile fish in nursery areas which are not identified as NTZs (e.g. mangrove ecosystems) may well increase, putting further pressure on connected marine ecosystems.

While the cumulative adverse impacts of overfishing, destructive fishing and coastal development have long been highlighted in the Coral Triangle region (Burke *et al.*, 2012), climate change is introducing new dimensions of socio-economic risk and uncertainty, including those relating to food security (Hoegh-Guldberg *et al.*, 2009). Rising water temperatures increasingly compromise the capacity of reefs to support fish populations, while also contributing to diseases such as ice-ice that impact seaweed cultivation plots throughout the region. This will likely enhance the pressure to adopt other alternative income-generating activities, which in turn will lead to greater instances of conflict with other resource users on land and sea.

CONCLUSIONS

The rights and ability of indigenous peoples to maintain their cultural identity through following traditional means of resource usage are subject to various conventions and treaties at the international level that seek to support indigenous identity and access to resources. However, the means and tools applied to operationalize sustainability objectives simultaneously place greater impositions on food access and availability. The latter are manifest clearly in Southeast Asia, where marine conservation has taken centre stage to the detriment of indigenous semi-migratory and nomadic peoples' ability to sustain their traditional means of collecting and utilizing marine resources. However, the links between marine conservation and food security are only beginning to be evaluated in the literature (Foale *et al.*, 2013); evidence supporting the positive impacts of MPAs in regard to maintaining or improving food security in marine resource-dependent communities is also lacking (HLPE, 2014). Clearly, vulnerable or marginalized populations that are wholly dependent on marine resources for food

and purchasing power for other foods and staples will be adversely impacted by restricted access, necessitating empowering these communities to contribute actively to decisions that impinge upon their livelihoods. There is an urgent need to refine marine policy-making so that food security and poverty alleviation are seen as integral and complementary to conservation objectives (Rockefeller Foundation, 2013). This includes consideration of social spaces along with biological imperatives as a foundation for marine resource planning and management and potential of rotational access and use within a larger network of MPAs, which incorporates larger migratory fishing territories. This could potentially address issues associated with sedentarization and overuse of resources.

Maritime semi-migratory and nomadic communities and women in particular are, furthermore, crucial partners in future initiatives to understand, monitor and address the impacts of climate change on marine food security. Hence, actively engaging them and seeking their support in contemporary conservation programmes will facilitate their involvement in designing programmes to ensure the long-term sustainable use of marine resources.

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Marine reserves and food security: why we failed so far to build robust evidence

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INTRODUCTION

The IUCN World Commission on Protected Areas (WCPA) recognizes six categories of marine protected areas (MPAs), ranging from marine reserves (also called no-take zones [NTZs]) in which all extractive activities are banned and access usually closed (IUCN Category 1) to complex multiple-use MPAs which are de facto a space-based multisectoral integrated management framework usually organized around one or more NTZs (Day *et al*., 2012).

In this paper, while at times alluding to the full range of MPAs, we focus largely on marine reserves. The aim is to examine the potential relation between the establishment of marine reserves and the level of human development of local populations living around them, with emphasis on their food security status. The fundamental question behind this study is "Do reserves contribute positively (or negatively) to the food security of local populations?" Although this question extends beyond aquatic environments and is also relevant to terrestrial reserves (see Hanauer and Canavire-Bacarreza, 2015), the focus is restrained to the marine and freshwater environment.[1]

The effect of protected areas (from national parks to reserves) on the well-being of their inhabitants and neighbouring populations is one of the most controversial debates in conservation policy (see Adams *et al*., 2004; Agrawal and Redford, 2006; Brockington, Igoe and Schmidt-Soltau, 2006; Wittemyer *et al*., 2008; Brockington and Wilkie, 2015). Two opposite mechanisms are most frequently cited, which frame this heated debate. On the one hand, protected areas are said to restrict access to natural resources, which reduces opportunities for local (economic) development and subsequently affects the well-being and welfare of the local populations, particularly in the case of (no-take) reserves that "push out" those who used to depend on these resources to sustain their livelihood and food security. On the other hand, protected areas are said to bolster ecosystem services, which, in turn, is expected to increase the future well-being and economic opportunities of the local populations (MEA, 2005).

Reflecting on the past experience of this debate, Adams and his colleagues recognized that "Clarity over the choices between biodiversity conservation and poverty elimination goals is essential. The desire to package projects as delivering win-win solutions plays down the incompatibilities between goals" (Adams *et al*., 2004: 1147). This tension between conservation and human development is particularly

[1] In the rest of this paper we use the terms MPAs and marine reserves, which should be seen as generally including freshwater equivalents as well.

contentious in developing nations and has intensified recently as these countries contemplate expanding and strengthening protected area systems to comply with their collective commitment to the Convention on Biological Diversity Aichi[2] targets to protect 17 percent of their terrestrial and inland water and 10 percent of their marine areas by 2020. The tension is likely to be worsened by the proposal at the last World Park Congress in Sydney to increase the extent of MPA coverage to having 30 percent of all ecosystems as no-take MPAs (marine reserves) (The 2014 Promise of Sydney).[3]

Part of the problem has been the inability of those involved in (or opposed to) the implementation of these protected areas to generate enough rigorous and robust evidence about the exact nature of the relation between conservation and local (human) development. In a recent in-depth review of the various governance innovations proposed (or imposed) in the past in relation to marine resource management, including the establishment of MPAs, Allison, Delaporte and Hellebrandt de Silva, (2013: 64) conclude: "Despite abundant claims, evidence linking governance innovations for marine resources to poverty reduction and/or food security is scarce at best (…). Not only is the evidence itself scarce, but there are shortcomings in all analyses due to inherent difficulties in measuring, estimating and/or comparing 'successful outcomes' of governance regimes – especially where poverty and food security are concerned." In the specific case of MPAs, their conclusion is even bleaker: "Non-existent. To our knowledge there is only one study that has explicitly linked MPAs with food security (…) [and] the evidence of impact is mixed" (Allison, Delaporte and Hellebrandt de Silva, 2013: 66). Other recent analyses confirm Allison, Delaporte and Hellebrandt de Silva's conclusion. Gurney *et al*. (2015: 1), for instance, in their analysis of the socio-economic impacts of MPAs, noted: "the evidence base for socio-economic impacts of protected areas, the cornerstones of many biodiversity interventions, is weak. (…) studies of socio-economic impacts of protected areas are dominated by qualitative case studies, and the few existing empirical studies tend not to focus on causal identification of impacts."

In this context, the objective of this paper is to build on these various reviews (see also Miteva *et al*., 2012; Garcia *et al*., 2013; Pullin *et al*., 2013) and to push the discussion one step further by exploring some of the main reasons why the different parties involved in the discussion around the implementation of marine reserves have, for their majority, failed to provide robust and consistent evidence about their impact on the food security status of the local neighbouring communities. However, in addressing this question it is argued that explaining the lack of rigorous/consistent data that impaired MPA studies by pointing at the absence of baseline and/or counterfactuals – as most of the recent reviews do (see Sutherland *et al*., 2004; Andam *et al*., 2010; Ferraro and Hanauer, 2014; Ahmadia *et al*., 2015) – misses part of the problem. Relying on a discourse analysis, we will show that this failure is not necessarily due to a lack of appreciation for basic monitoring and evaluation principles, but reflects instead the rhetorical argument and advocacy nature of the process on which the decision to establish a marine reserve is usually based.

In the second part of this paper, a more standard impact evaluation framework is adopted to revisit the same question and build the generic Theory of Change (ToC) related to the effect of marine reserves on food security. Using this generic ToC framework, we will then show why, with a baseline/endline approach or even a treatment/control protocol, most of the quasi-experimental approaches published in the last few years in the literature are still unable to determine how and why a marine reserve does (or does not) contribute to the food security of the local population. In doing so we also identify what should be a more appropriate approach to assess rigorously the impact of marine reserves on food security.

[2] https://www.cbd.int/sp/targets/

[3] worldparkscongress.org/about/promise_of_sydney.html

DISCOURSE ANALYSIS ON MPAS

A "discourse is a shared way of apprehending the world. Embedded in language, it enables those who subscribe to it to interpret bits of information and put them together into coherent stories or accounts. Each discourse rests on assumptions, judgements, and contentions that provide the basic terms for analysis, debates, agreements and disagreements" (Drysek, 1997: 8). Understanding narrative is, therefore, critical in relation to science, expertise and the ways knowledge can be used, silenced or instrumentalized to justify or legitimize particular decisions and policy orientations. In the context of MPAs, where scientific expertise plays a major role in framing the policy debate, it can be argued that any narrative which becomes dominant among experts will be instrumental in shaping the way MPAs will be conceived, implemented and therefore evaluated.

In this section we will use a discourse analysis (applied in a relatively loose manner) to deconstruct narratives and discourses (understood in Drysek's sense) around the debates on MPAs and food security, highlighting in particular their "internal logic" and how they were shaped and influenced by the wider debate on conservation versus poverty alleviation. To do so, a small number of articles have been pulled out of the literature in an attempt to illustrate certain points. This small pool of scientific articles does not offer in any way a comprehensive (or systematic) review of the literature, nor does it provide a statistically representative sample of it. The primary objective, instead, is to identify the main narratives as they are proposed in the related literature and to organize them into a coherent analysis that sheds light on the past and current discussions and eventually provides some explanation for the lack of rigorous and robust data which is impairing the current assessment of marine reserves in relation to food security.

Marine reserves, conservation and fisheries management – a win-win co-optation?

The recognition that global efforts to maintain biodiversity could be in conflict with those to reduce poverty is not new – see Wells (1992); Norton-Griffiths and Southey (1995); Brockington (2002); Sanderson and Redford (2003). Since the late nineteenth century the conventional response to the threats of decline of natural populations, extinction of species and habitat degradation as a consequence of industrial development has been the creation of protected areas (Adams, 2004). The problem is that, in the case of reserves, this strategy can have substantial negative impacts on local people. The eviction of former occupiers or right holders from land or marine resources is said to cause the exacerbation of poverty, as well as contravention of legal or human rights (Colchester, 2002; Fortwangler, 2003). Globally, it is recognized that the costs of biodiversity conservation are not distributed among people in proportion to the benefits they derive from it (Wells, 1992). Typically, many of the costs of protected areas in poor biodiverse countries are paid by local people (Roe and Elliott, 2004).

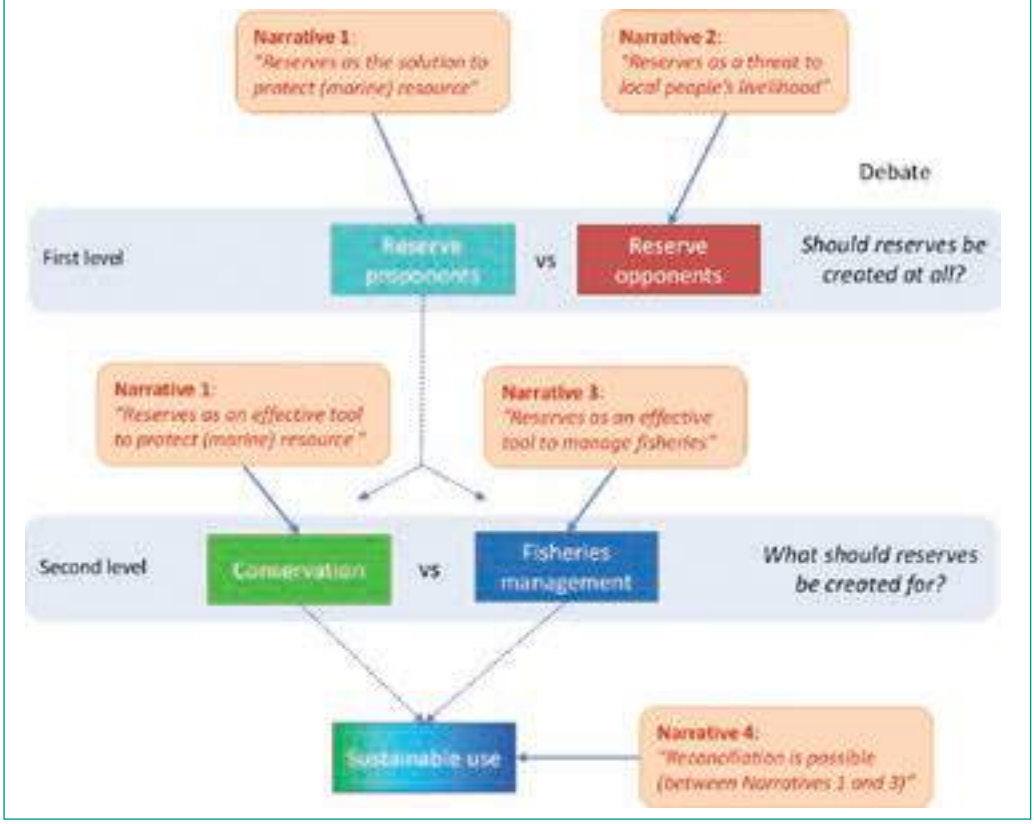
From a narrative analysis perspective, this debate captures or reflects the conflicting views represented by two divergent discourses: on the one hand, to those whose main interest is the (ecological) conservation or restoration of ecosystem health and services, protected areas (especially reserves) are the solution because their restrictions on natural resource use protect biological systems that, in the long term, would otherwise be depleted, degraded or destroyed. On the other end of the spectrum, for those concerned by (human) considerations such as equity and social justice as well as poverty alleviation, reserves are the problem, as they threaten peoples' rights and livelihoods both in the short and long terms. When imposed top-down, they are often excluding a part of the society (the local population living in the vicinities of the reserves) for the benefits of the rest of the (global) population. In sum, as Brockington and Wilkie

(2015: 1) summarize it "Protected areas' distribution of fortune and misfortune [i.e. distribution of benefits and costs] lies at the heart of their controversies".

Marine reserves did not stay out of this controversy. In this case, however, the divide turned into a two-level nested debate (cf. Figure 1). The first level reflects, and can to a large extent be conflated with the more generic debate on "conservation versus poverty alleviation" presented just above. It ranges between two ends – on one of which are to be found those concerned primarily with the preservation of marine and freshwater resources (e.g. most conservation NGOs, marine biologists/ecologists and other environmentalists) who fight for the protection of the environment and see reserves as a way to reduce or eliminate human pressure on these resources. For these, "A reserve is the solution (to protect marine resources)" (Narrative No. 1). On the other end of the spectrum are to be found the other group, made up of the opponents to reserves, including fishers, social activists, and those among social scientists and academics, who see them as a threat to the livelihoods and rights of (often poor and marginalized) fishing communities" (Narrative No. 2). Between these two groups, the debate is "deep and entrenched"; it is about whether reserves should or should not be created at all, from a social justice vs conservation perspective.

The second level of the debate is nested in this first level. At that second sublevel, the divergence is not about the existence of reserves *per se* (as that existence is not questioned) but about the priorities among the objectives of these reserves. More specifically, it is about whether and to what extent reserves (which are primarily for biodiversity protection) could also have a positive impact on fisheries and hence be supported (instead of opposed) by fishers. As such it takes place between on one hand the proponents of reserves for whom "reserves are an effective tool to protect (marine) resource" (Narrative No. 1), and on the other hand those interested in the sustainable

FIGURE 1
The two-level debate and associated narratives about no-take reserves in the fisheries context



Source: Author.

management of fisheries (fisheries experts, managers and fishery scientists) for whom "reserves could be used to contribute to that sustainable management" (Narrative No. 3). In this second-level debate, there are of course some variations in-between (some for instance among those interested in the sustainable management of fisheries still consider that well-managed fisheries do not need reserves) but overall the disagreement here is not whether reserves should or should not be created, but rather what they should be created for: protecting marine resources (from fisheries pressure), or ensuring a sustainable and possibly more efficient use of fisheries resources.

Interestingly, this last divide has evolved over time and the two communities have in particular converged recently in what could be seen as an attempt to "bridge" (Weigel *et al*., 2014) or to "reconcile" (Rice *et al*., 2012) fisheries management with conservation objectives (Narrative No. 4). Rice and his 17 co-authors for instance talk about a "convergence of perspectives" and "areas of dialogue on MPAs (in general) and fisheries" (Rice *et al*., 2012: 218). Likewise, Weigel *et al*. refer to "a new dialogue (…) emerging towards a convergence of these overlapping goals and a better understanding of the potential trade-offs between biodiversity conservation and fisheries management in MPAs" (Weigel *et al*., 2014: 200). After all, as Rice and his co-authors put it (2012: 228): "Objectives for both fisheries management and biodiversity conservation have common goals of sustaining habitats and resources" (author's emphasis). The way out of the divide is, therefore, to identify these areas of common interests and to build upon them to reconcile the two narratives. This position is facilitated by the fact that the range of MPAs that can be considered allow for a wide range of use and protection within which agreement may be more easily found.

In that search for a common goal, the core questions become mainly technical: "what is an appropriate balance of priority to conservation of biological diversity and to sustainable use of living marine resources (…); how should [MPAs] be designed and managed; what are appropriate roles of diverse agencies, industries and communities in the planning processes, and in management once MPAs are established?" (Rice *et al*., 2012: 218). This search for solutions has not just been technical, however, and political or governance dimensions were also brought into the equation. Weigel *et al*. (2014) for instance point out that one of the key lessons from past experience about MPAs is that principles of good governance such as "Includ[ing] fishers in the design and ongoing management of MPAs; Creat[ing] spaces for sharing and processes for meaningful engagement; Recogniz[ing] access rights and tenure; or Consider[ing] equity in processes and outcomes" should be underpinning any integrated approach bridging biodiversity conservation and fisheries management in MPAs (Weigel *et al*., 2014: 212) – see also FAO (2011); ICSF (2012); Bennett and Dearden (2014). This need for more "legitimacy, transparency, equity, accountability, inclusiveness, fairness" (Weigel *et al*, 2014: 213) emerges from the recognition that most of the conservation-driven MPA projects in the past have been imposed on the local populations in a top-down, unparticipatory, manner by external parties – often international conservation NGO "experts" – whose ultimate agenda was to ensure that natural resources were protected, not that local populations were benefitting from it (Christie, 2004; Charles and Wilson, 2009; Bavinck and Vivekanandan, 2011).

However, it is not necessarily a revolutionary "conclusion" to state that an improved MPA arrangement would be one that relies on a more inclusive governance system. In fact, the principle that the needs of local people should be more systematically integrated into protected-area planning had already been stressed at the third World Parks Congress in Bali in 1982 (Phillips, 2002). What is important to realize, however, is that in this discussion we passed from a situation which was denying the local fishing communities the right to decide whether or not a MPAs could or should be created on the fishing ground where they used to fish, to an "improved" situation whereby they ought to be now included in the decision-making process. But in the process, one

important decision has already been made: the option of no-MPA is excluded from the set of possible solutions.

In sum, the reconciliation process that has been proposed around MPAs in the context of fisheries is one which reduced the problem to a search for trade-offs between conservation and fisheries management objectives. While inclusive and better governance was recognized to be a necessary condition for success in such a process, it seems to also assume that this is a sufficient condition. In this context, the new "integrating" approach implicitly co-opts the fishing communities into a decision process where the "no MPA" is not an option. By so doing, it leaves out the most polemical (political) claim which was initially underpinning the original narrative around reserves – the claim that the creation of reserves threatens the livelihoods of the fishing communities. In essence, what is eventually presented as a win-win situation is one where the reserve is created anyway, even though the local population might be able to influence the decision regarding the size and location of the reserve.

Food security and marine reserves – is rhetoric good enough?

Little reference has been made so far in this discussion to the issue of food security. This is not surprising for two main reasons. First, even understood in the broad sense of "reducing hunger and malnutrition,"[4] food security has not been part of the mainstream discourse in fisheries management sciences in general, at least until recently (Béné *et al*., 2015). As pointed out by the 2014 High Level Panel of Experts' (HLPE) report on food security in fisheries and aquaculture, "Specialist fisheries debates have concentrated predominantly on questions of biological sustainability and on the economic efficiency of fisheries, neglecting issues linked to their contribution to reducing hunger and malnutrition and to supporting livelihoods" (HLPE, 2014: 14). Despite a few earlier studies stressing the importance of fish in relation to food security (see Béné, Macfadayen and Allison, 2007; Heck, Béné and Reyes-Gaskin, 2007), only very recently has the issue of food security emerged more consistently in the fisheries literature (Garcia and Rosenberg, 2010; Rice and Garcia, 2011; De Schutter, 2012; Kawazuka and Béné, 2010; Allison, 2011), possibly in response to the wider debate on food security (Godfray *et al*., 2010). The nutrition and health benefits of fish consumption continue to be a hot topic in research, mainly centred around the role of polyunsaturated fatty acids in preventing heart disease, in a global context where non-communicable diseases (cancer, heart disease, diabetes, etc.) are now the largest cause of mortality (Ng *et al*., 2014). The role of fish and other seafood in providing micronutrients is also gradually appreciated in the context of an increasing focus on the "hidden hunger" of micronutrient deficiencies in low-income countries (Allison, 2011; Kawarazuka and Béné, 2011). There is an emerging understanding of the multiple ways in which fisheries support food security, both directly and indirectly (Kurien, 2004; Kawarazuka and Béné, 2010; De Schutter, 2012; HLPE, 2014) but, as yet, there has been little analysis of how proposed fishery governance reforms (including the creation of various types of MPAs) will impact on those, such as fisherfolk, who rely on common property resources for food and income, and low-income consumers who obtain nutrition benefits by consuming lower-value fish.

Second, and even more specifically related to the debate on marine reserves, food security is not presented as a key argument in any of the four narratives above. At best it is implicitly assumed to be affected positively in the fisheries-reserve Narrative No. 3 (where a well-managed fishery with reserves is assumed to support food security), while it is assumed to be negatively affected in the fishing community Narrative No. 2, where the denial of access to fishing ground is expected to impact on the food security of the local population (at least in the short term). Several authors recognized, however, that when it is mentioned explicitly this is usually only in a rhetorical way. Weigel *et al*.

[4] See the second part of this paper for a more formal definition of food security.

(2014: 209) for instance point out that "Most of the time food security (as an objective or positive externality [of MPAs]) is used rhetorically"[5].

A more in-depth review of the literature would reveal that the supposedly positive relation between MPAs in general and food security (more often reflected in the recent literature advocating MPAs) is effectively very rarely rigorously tested. In their thorough analysis, Allison and his colleagues (2013) found that among the large pool of studies they reviewed, only one study in the Solomon Islands applies a rigorous design to test the relation between the creation of an MPA and the food security status of the neighbouring communities (Aswani and Furusawa, 2007). In that case, the evidence of impact was found to be mixed. One other study, which was not included in Allison, Delaporte and Hellebrandt de Silva's review, could also be considered as a robust analysis: it uses a form of counterfactual analysis (what would have been the situation had the MPAs not been implemented). However, the study did not look at food security *per se* (or nutrition) but at poverty level instead (Andam *et al*., 2010). In sum, finding rigorous studies that substantiate the implicit assumption that MPAs can improve the food security of the local population – or conversely degrade it – seems more difficult than one would have thought initially.

Two main reasons can be proposed to explain this situation. First, as noted above, the question of the food security of fishing communities affected by the creation of a reserve is not a keystone element in the articulation for any of the narratives around reserves. Both conservation and conventional fisheries management narratives rely more on the ecological side of the storyline, and have, therefore, far stronger incentives to develop rigorous protocols that would allow them to "justify" (*ex ante*) or to "validate" (*ex post*) the establishment of the reserves based on biodiversity or species abundance indicators, than they have to develop protocols that would allow them to test whether a reserve affects positively (or negatively) the food security of local communities. For these two narratives, a rhetorical discourse about food security seems to be good enough. Furthermore, the decision to establish a reserve, or series of reserves, in a particular region/country often results from top-down political decisions taken in a context of strong pro-MPA advocacy by environmental activists and/or international and national conservation NGOs on the basis of the perceived or actual degradation of the global or local environment, rarely supported (at least in the past) by the scientific rigour of a specific evidence-based process. In those conditions, where lobbying and advocacy rather than science and local knowledge, leads the decision process, the pressure to document the actual effects of the projects are reduced considerably, resulting in situations where very few of these projects were encouraged to establish a proper baseline (often even for their key conservation objectives). Besides, as has been claimed above, when these baselines were established, these were essentially focusing on the ecological changes expected to occur within the protected areas, rather than on the social or even economic processes expected to change outside them (see Willis *et al*., 2003; Claudet *et al*., 2006).

On the other hand, for opponents to the creation of marine reserves, who claimed that their establishment affect negatively local communities, the incentives to document more rigorously the socio-economic impact of the measure appear to be far stronger. In these cases a "rhetoric-is-good-enough" approach is not good enough and the absence of rigorous studies/baselines which is observed in the literature is more difficult to explain. One potential explanation for this paradox is to recognize that these impact evaluations are relatively costly and need to be implemented in a timely manner (i.e. just before the reserve is established, for the baseline). This methodological

[5] They themselves, however, also contribute to this rhetoric in an earlier statement made in the same paper where they state: "The positive fisheries effects of MPAs can lead to increased food and livelihood security in local fishing communities (Roberts *et al*., 2001; Sanchirico and Wilen, 2002)" (Ibid: 202). The problem is that neither of the two references they quote did effectively look at food security.

and financial constraint means that individuals (academic, human right activist) or groups/NGOs interested in documenting the precise effect of a new reserve on the local population would have to find a substantial amount of money in a relatively short period of time (usually from donors). The question then becomes: which donor would be willing to finance such evaluations and in so doing to take the risk to support a research project which is potentially going to highlight the negative social impact of a newly established reserve –likely to have been funded by another donor or by a national government? The situation has been changing slowly during the last decade (as seen in Weigel *et al*., and in Garcia, *et al*., 2013) but there is still too little information to fully appreciate these impacts, particularly in the long term. In any case, local food security impacts remain poorly addressed.

In sum, it seems that the lack of interest by some powerful groups in bringing the question of food security in relation to marine reserves beyond its rhetorical stage, combined with the realpolitik of donor-supported research-in-development altogether offer a reasonably well-grounded hypothesis on why so few of these socio-economic baselines have been established and so few ex ante and ex post studies of socio-economic impacts implemented.

A second reason for the absence of many robust assessments – or the inconsistency and weaknesses of the few existing ones – can be found in a growing number of papers written by scholars who advocate for an experimental (or quasi-experimental) approach to environmental assessments (e.g. Ferraro, 2009; Ferraro and Hanauer, 2014; Ahmadia *et al*., 2015; Pressey, Visconti and Ferraro, 2015). For these hard-core impact assessment proponents, the problem is not about the realpolitik of funding potentially confronting research, but lies in the technical failure of past studies to adopt a rigorous design, leading to non-existent, weak or unreliable results. Gurney and her co-authors for instance remark: "Despite enthusiasm to move beyond 'conservation practice based on anecdote and myth', evidence-based conservation is severely impaired by a lack of knowledge, or evidence, of what conservation actions work, where they work or not and why" (Gurney *et al*., 2015: 1).

What is proposed in the next section is to explore this new area of experimental or quasi-experimental impact assessment design. However, instead of simply reviewing the findings that those more rigorous impact evaluations have generated, the discussion aims to demonstrate why, even with a baseline/endline approach or a treatment/control protocol, most of these quasi-experimental approaches would still have difficulties to determine how and why a reserve does (or does not) contribute to improve the food security status of the local population living in or around it. The argument advanced is that the potential causal pathway between outputs (the establishment of the reserve) and the ultimate impact under consideration (food security of the local population) is far more complex than some other more direct impact interventions have on ecological outcomes such as biodiversity or resources abundance; and that the black-box approach (input-output analysis) which often characterizes these experimental/quasi-experimental studies is not appropriate to capture this complexity.

CAUSAL PATHWAY ANALYSIS OF MARINE RESERVES' IMPACTS ON LOCAL POPULATION'S FOOD SECURITY

Generic Theory of Change

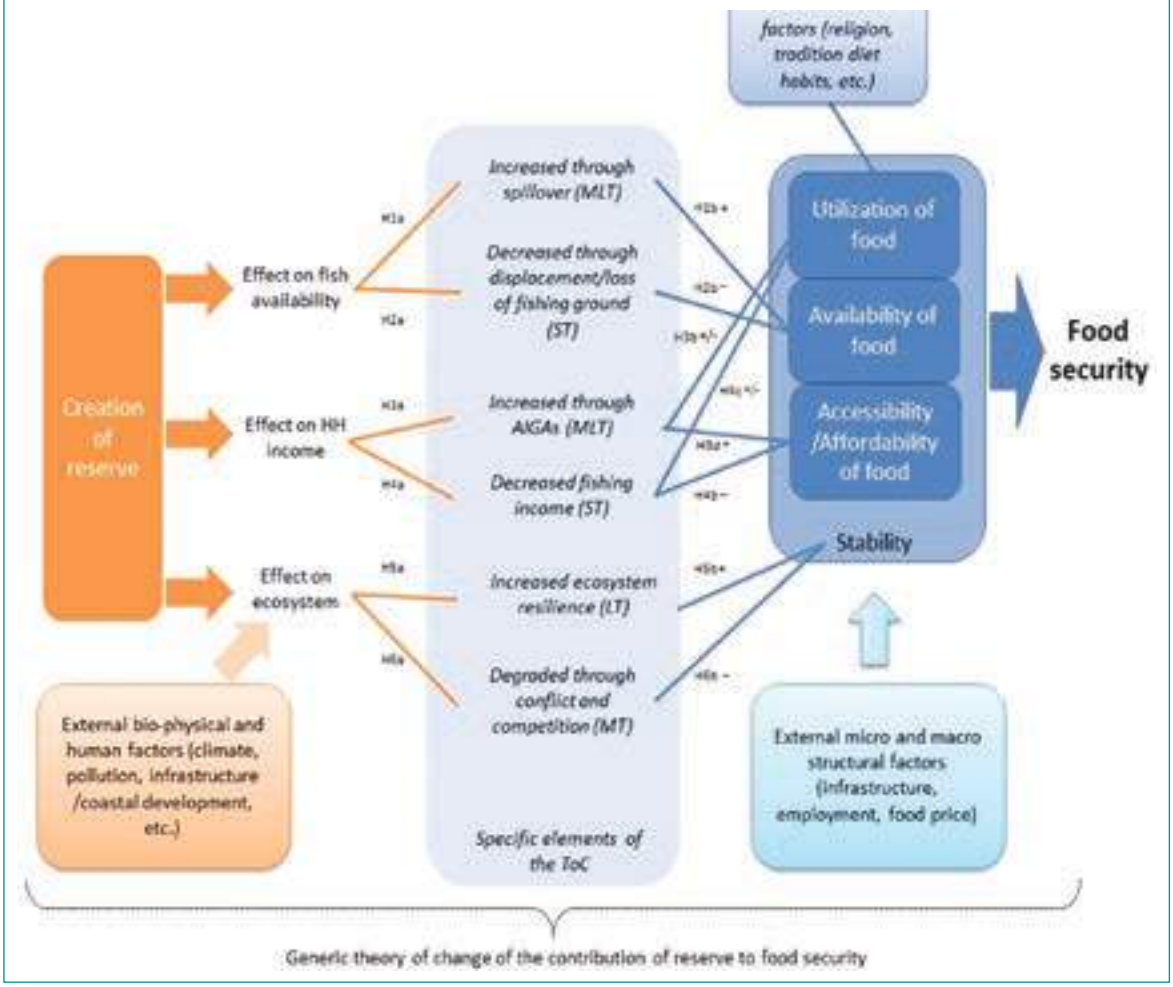
A central element in this second part of our analysis is the building of the generic Theory of Change (ToC) describing the causal effects of marine reserves on food security. Even if many scholars already use ToCs as a planning tool in their proposals or in their strategic thinking to structure their research, it may be useful to recall succinctly what a theory of change is. Put simply, a ToC can be understood as a way to describe the set of assumptions that explain both the different steps that lead to a longer-term goal and the

connections between these steps, and the outcomes of an intervention or programme. To some extent a ToC shares a lot of similarity with another tool which researchers also increasingly use, the impact pathway, in the sense that both ToC and impact pathways describe the different steps (chain of events) through which one needs to go to make a specific change happen. The main difference between a ToC and an impact pathway, however, is that a properly implemented ToC would specifically identify and articulate the key assumptions that need to be satisfied at each step along the chain of events for the change to happen.

In Figure 2, we propose a generic ToC which reflects the general understanding of how reserves are expected to affect the food security of local fishing population. Taken one by one, none of the different elements that constitute the different causal pathways presented in Figure 2 is fundamentally new.

FIGURE 2

Generic theory of change of the contribution of reserves to the food security of the local population



Note: ST = short terms; MLT = medium to long terms; MT = medium terms; LT = long terms; HH = households.
Source: Author.

The four dimensions of food security

Starting with the element on the right-hand side of Figure 2, the four dimensions of food security are represented as now widely accepted in the international literature (FAO, 2008).[6] These four dimensions are:

Food utilization. Utilization is recognized to be the result of good care and feeding practices, food preparation, diversity of the diet and the intra-household distribution of food. As such, it is essentially influenced by "external" socio-cultural factors such as education and diet habits, but also to some extent by the level of local infrastructures (such as presence/absence of health facilities, drinking water facilities, etc.) and households' access to these – therefore partially dependent on the households' income.

Physical availability of food. This represents the "supply side" of food security, determined by the level of food production, stock levels and net trade. In this case, this refers to the amount of fish that are caught (outside the marine reserve) and available at the household and local market levels.

Economic access to/affordability of food. This relates essentially to the differential between household incomes and (local) food prices. In this case, this refers to the affordability of local fish but also other local and imported food products, relative to the income of the fishing households.

Finally the fourth dimension of food security is the **stability of the other three dimensions over time.** In the general context, this refers to the effects of shocks/stressors such as adverse weather conditions, political instability or economic factors (unemployment, rising food prices). In this case, it also may include the potential impact of conflicts/competition between fishers for the resource or the (improved or degraded) condition of the local ecosystem.

Figure 2 indicates that these four different dimensions of food security will be affected by the different (intended and unintended) chains of events triggered by the creation of the marine reserves (represented by the dark blue links coming from the local-specific element of the ToC in the diagram[7]) but also by "external" conditions which characterize the wider local social and economic environment, including culture and food consumption habits, as well as the general level of poverty, access to local infrastructure and public services, or level of employment outside the fishery.[8]

Direct effect of marine reserves

On the left-hand side of Figure 2 we represented the three main direct effects of marine reserves as usually presented in the literature: (i) effect on fish availability/accessibility; (ii) effect on fisher's income, and (iii) effect on the local ecosystem (Garcia *et al*., 2013). These three effects are detailed below. Note from the outset, however, that all of these three direct effects can have both positive and negative components.

Effect on fish availability

Generally, the literature has confirmed the positive biological effects of reserves on abundance, biodiversity and average size of species within the reserve (Lester *et al*., 2009; FAO, 2011), except in the case of sedentary animals (e.g. gastropod) for which crowding effect can occur (Béné and Tewfik, 2003). The improved status of the populations within reserve boundaries and the larval and/or adult spillover in the surrounding areas are then expected to increase catches outside the reserves within a few years to decades from reserve establishment. This effect, which has been extensively

[6] Note that for clarity reasons, these four dimensions are not represented on Figure 2 in the same order as they are usually presented in the literature.

[7] Note the positive and negative signs associated with these links, meaning that these chains of events will affect positively and/or negatively these different dimensions of food security.

[8] Note that potential positive or negative feedback effects are not represented here. One could, for instance, imagine that change in fishing households' income will have subsequent influence on their fishing behaviors, which itself may eventually affect the wider ecosystem conditions.

investigated through modelling (see Lauck *et al*., 1998; Doyen and Béné, 2003; Fulton *et al*., 2015) has also been documented empirically for conservation reserves and fisheries closures in coral reefs, temperate rocky reefs, continental shelf and estuarine environments (Gell and Roberts, 2003; Halpern, 2003; Micheli *et al*., 2004; Goñi *et al*., 2008; Harrison *et al*., 2012). This positive effect is represented by the Hypothesis H1a in Figure 2.

The spillover effect, outside the reserve, although difficult to study, has often been measured by the analysis of the distribution of catches as a function of their distance from the reserve boundary (if the reserve was not located, to start with, in the area with the highest abundance of fishery resources). The empirical evidence typically shows fairly localized effects, with increased catches within hundreds of metres to a few kilometres from the reserve boundaries (McClanahan and Kaunda-Arara, 1996; Russ, Alcala and Maypa, 2003). Overall, however, the spillover effect has variable results depending on whether the increased catch rates around the reserve compensate for the losses associated with the closure of the areas which used to be fishing grounds (Hatcher, 1998; McClanahan and Mangi, 2000; Russ *et al*., 2008). This possible compensation is represented by the Hypothesis H2a in Figure 2. Based on their in-depth review of the literature, Garcia and his co-authors concluded on this issue: "As a rule and except for a few little atolls, studies show that spillover effects are not very often sufficient to compensate direct catch losses due to an access restriction to fishing zones" (Garcia *et al*., 2013: 26).

Effect on income

To compensate for the loss of access to previous fishing grounds, in the case of a reserve, national authorities or project implementers (e.g. NGOs) do sometimes provide either direct compensation (e.g. donations, purchase of gear) or indirect assistance (e.g. through port infrastructures, provision of fish aggregating devices (FADs)). The most frequent type of intervention, however, is through the introduction of alternative income-generating activities (AIGAs) to fishers and other members of the communities (e.g. fish traders)(MMO, 2013). Examples include development of ecotourism (Gossling, 1999; Deheunynck *et al*., 2004); or land-based animal or vegetable production (wildlife, aquaculture). These different AIGAs are expected to improve the overall income of the households and community – Hypothesis H3a in Figure 2 – and, therefore compensate for the loss of direct income that follows the closure of the fishing grounds (Hypothesis H4a). Unfortunately, very few studies provide concrete information about these AIGAs. On this issue, Garcia and his co-authors concluded that projects of AIGAs developed for the benefits of fishers "remain often anecdotal or weakly sustainable" (Garcia *et al*., 2013: 30), and rarely maintain long-term positive economic results for the stakeholders involved.

Effect on the local ecosystem

Partially related to the first effect on the fishery resource, the third effect of the creation of reserves (or core reserves in multiuse MPAs) usually mentioned in the literature is the effect on the wider ecosystem. Reserves are often said to improve the stability or even the resilience of the local ecosystem (IUCN/WCPA, 2008; Jones, 2014). This effect, which goes beyond the direct effect on the species that were initially targeted by the fishery, concerns the other fish and marine species (as well as their habitats) and their ecological interactions, and refers loosely to the general "health" of the local ecosystem. In some other cases the term "resilience" makes more specifically (or more correctly) reference to the ability of the local ecosystem to bounce back more rapidly after a shock, or to maintain more effectively its structure and key functions when affected by a stressor. The underlying idea is that higher functional diversity (that may result from the protective effect of the MPA on a degraded marine ecosystem and its

resources) would play a critical role in building the resistance of the system to shocks or stressors, including fishing pressure or its capacity to adapt to, for example, climate shocks (Sumaila *et al*., 2000; Stelzenmüller, Maynou and Martin, 2009), leading to the overall greater resilience of the system (Hypothesis H5a). This rather theoretical causal effect has not really been confirmed empirically. Modelling on the other hand seems to suggest that this positive effect is possible (Grafton, Kompas and Lindenmayer, 2005; Doyen *et al*., 2007).

The opposite scenario is one where conflict, displacement and competition between fishers, following the establishment of the reserve, lead to higher pressure on the ecosystem around it or at distance from it and eventually to a more degraded ecosystem (Hypothesis H6a). The situation is somehow paradoxical as MPAs, of all forms, are often presented as efficient spatial management tools, but empirical evidence suggests that the outcomes can be different. McClanahan and Mangi (2000) for instance report that in Kenya, conflicts have increased between different MPA users and different gear users once a multiuse MPA was implemented.

MULTIPLE PATHWAYS AFFECTING SEVERAL DIMENSIONS OF FOOD SECURITY

Not only does each of these three main pathways include positive *and* negative effects of the same parameter (e.g. household income tends to increase through successful AIGAs and simultaneously to decrease through decline in direct fishing income). However, the literature also tells us that different parameters may change simultaneously (e.g. changes in fish availability, income and ecosystem conditions), possibly combining their effects. In other words, talking about *one* causal pathway between reserves and food security does not make sense. Instead there is a multiple causal pathways map. Those multiple pathways also affect the four different dimensions of food security differently. For instance, the decrease in fishing income induced by the closure of the fishery in the reserve or in the NTZ of a multiuse MPA is expected to affect negatively the accessibility to/affordability of food (negative sign of the Hypothesis H4b) but also the utilization of food through, for instance, the general degradation of the living standard of these fishing households. Note, however, that the sign of this link to food utilization is not necessarily clear (as indicated by the +/_ symbol associated with Hypothesis H4c), as changes in food habit may result in either positive and/or negative consequence for food security.

The overall change in food security is, therefore, difficult (a) to predict accurately and (b) to assess comprehensively:

a. It is difficult to predict because the multiple pathways act separately but conjointly on different dimensions of food security. For instance, it is easy to imagine a situation where a positive spillover effect leads to a positive effect on food availability (Hypothesis H1b), while at the same time the same spillover effect is not sufficient to compensate for the decline in fishing income, and the resulting decline in household revenues affects negatively the accessibility/affordability of food (Hypothesis H4b). The global food security of the households is, therefore, affected both positively and negatively, and it will be difficult to predict the sign of the final outcome of the establishment of a reserve.

b. This overall change in food security is also difficult to assess and capture comprehensively unless indicators have been included to monitor independently its four different dimensions. In none of the studies that claim to assess the impact of reserves on food security (even the more rigorous ones which rely on an "improved" evaluation design) has there been a discussion on this issue, raising some serious question marks about their actual ability to effectively answer the question they proposed to address.

LOCAL AND TIME SPECIFICITY OF THE IMPACT PATHWAY AND THEIR CAUSAL MECHANISMS

The next step is to recognize that the series of subsequent steps which constitute each of these different impact pathways (taken individually) are location and time specific, and that these steps need, therefore, to be identified and studied within this context. This specificity does not only affect the direct causal mechanisms that link one step to the next along one pathway, leading to intended or unintended changes in outcomes and impact, but applies also to the confounding factors (that is, the factors that affect both the outcomes and the initial decision about the establishment of the reserve, such as its location). For instance, in the case of the positive effect of marine reserves on fish availability outside them (Hypothesis H1a), it is now widely accepted that spillover and recruitment benefits to fisheries can be large, moderate or negligible, depending on a number of case-specific factors such as the ecological setting of the reserve, how they are managed and the existence of other fisheries management measures around the reserve such as strict capacity control (Hilborn *et al*., 2004; Stewart *et al*., 2009; Goñi *et al*., 2010; Russ and Alcala, 2011).

As acknowledged by Rice *et al*. (2012: 219) in the case of MPAs in general: "There is no simple answer to the question of whether such "fisheries MPAs" had positive, negative or no consequences (…). The systems being managed are complex, diverse and dynamic, and it is difficult to show direct cause and effect linkages of fisheries closures and biodiversity outcomes. Rather, the outcomes are situation and time specific, and even what constitutes a benefit depends on the perspective of those doing the evaluation (our emphasis)." This "situation and time specific[ity]" does not apply, however, just to the fish availability causal pathway as discussed by Rice and his colleagues. It also characterizes the two other pathways (income and ecosystem) – see e.g. Christie *et al*. (2003) or Cinner (2007) for articles highlighting the importance of accounting for the local specificity of social processes in relation to MPAs – leading each time to a highly specific, and almost unique "maze" of causal paths linking the initial effects to the ultimate outcomes. This local specificity is highlighted in the light blue area in the central part of Figure 2.

In addition, the time specificity of these different causal pathways also needs to be accounted for. The decreased availability of fish through the displacement of fishers out of the reserve, for instance, is instantaneous; and so is the decrease in their fishing income. In contrast, the potential spillover effect, if it happens, is usually recognized to happen after a few years. Babcock *et al*. (2010), for instance, estimate that on average, the direct effects inside reserves start to be visible after 5 to 7 years, whereas indirect effects (resulting from interactions among species) are detected after 11 to 15 years. The full benefits of a reserve are generally observed only after a long time (10 to 40 years). Several studies show that restoration/stabilization of biomass to the carrying capacity of the area requires protection over a long time (several decades) (Babcock *et al*., 2010). Likewise, the potential positive effects on the wider ecosystem (stability, resilience), if they occur, are expected to be long-term effects (LT), while conflict and competition are usually observed to be medium-term (MT) effects. Similar comments apply to the economic and income effects: potential compensation effects through successfully implemented AIGAs may take several years to occur, while, as mentioned above, reduction in fishing income is instantaneous. In sum, depending on when the assessment is conducted, the effects observed and measured are likely to be different, with negative effects usually appearing first, with more positive effects, if they occur, taking place much later. This means that a "before-after" assessment reflecting a baseline-endline framework would not even be sufficient; what is needed instead is a "before-after-and-later" framework.

QUASI-EXPERIMENTAL ASSESSMENTS: BETTER, YET NOT PERFECT

What emerges from this analysis is a "messy" landscape where marine reserves' direct and indirect effects affect in different ways multiple aspects or dimensions of food security of fishing households, operating at different time scales and through a combination of multiple, local-specific causal pathways which reinforce and at the same time counteract each other's effects.

The quasi-experimental assessment approaches,[9] advocated by the proponents of more rigorous impact assessment (e.g. Ferraro and Hanauer, 2014; Ahmadia *et al*., 2015; Pressey, Visconti and Ferraro, 2015), are with no doubt an improvement compared to the narrative-driven approach which has characterized the MPA literature for (too) many decades. These scholars, however, seem to be too confident in the rigour of their approach and fail to realize that many of the baseline-endline frameworks that they propose are designed as black-boxes linking the initial output (presence of a reserve) to some indicators of the ultimate impact (in the best case, one indicator of food security) and comparing it against some form of counterfactual,[10] and as such are not well adapted to identify and test the causal pathway(s) through which these changes take place. Indeed, while the rigour of their assessment framework puts them in the position to assert with some degree of confidence whether the creation of the reserve may have contributed or not to the observed change in the food security indicator, the black-box nature of the approach does not allow them to say much about the intermediate outcomes and the pathways which lead to the ultimate impact and, in particular, whether the +/- impact observed is really related to the creation of the reserve, environmental oscillations or changes in the overall area context (demography, demand, trade, migrations, climate change, etc.).

A good illustration of this is the recent analysis of the link between MPAs and poverty proposed by Andam *et al*. (2010). In that analysis the authors wanted to determine whether the assumption about the high poverty levels that are sometimes associated with the establishment of protected areas, is empirically well grounded (Ghimire and Pimbert, 1997; Cernea and Schmidt-Soltau, 2006; Upton *et al*., 2008). They justify their investigation by pointing out (correctly) that a lot of the studies which looked at this issue so far did not clearly demonstrate a causal link between protection and poverty because they failed to control for confounding effects of geographic and baseline characteristics. Using household data from Thailand and Costa Rica and relying on matching methods to select appropriate control communities, Andam and his co-authors then compared communities heavily affected by protected areas (treated) with similar communities that are less affected by protected areas (controls). Matched control communities were chosen to be similar to treated communities with respect to confounding baseline characteristics. Their analysis shows that, although communities near protected areas are indeed substantially poorer than national averages, the data do not support the hypothesis that these differences can be attributed to protected areas. To the contrary, the authors claim that their results indicate that the net impact of ecosystem protection has been to partially protect the communities around the MPAs from the growing poverty affecting the whole country/area.

The problem is that their analysis simply compares poverty indicators (poverty index and poverty headcount) between regions (those close to protected areas and

[9] Quai-experimental approaches are empirical analyses used to estimate the causal impact of an intervention (in our case the creation of reserves) on its target population. Quasi-experimental research shares similarities with the traditional experimental design or randomized controlled trial (RCTs), but they specifically lack the element of random assignment to treatment or control. Quasi-experimental methods include matching, differencing, instrumental variables and the pipeline approach; they are usually carried out by multivariate regression analysis.

[10] A "counterfactual" measures what would have happened in the absence of the intervention (i.e. in the absence of the creation of the reserve), and in a rigorous impact assessment, the impact is estimated by comparing counterfactual outcomes to those observed under the intervention.

those located further away), controlling for potential confounding factors (i.e. factors that may have affected both the placement of protected areas and how poverty changes over time). This, unfortunately, tells us little about how MPAs appear to reduce poverty. To some extent Andam's study is more rigorous but not more insightful than the previous analyses it claims to replace.

What would be more useful is to test some of the intermediate outcomes or, more specifically, the underlying hypotheses that underpin the chain of events constituting the ToC of the projects considered. In particular, because Andam's study was focusing on the income-poverty dimension of the link between reserves and well-being of the local populations, it would be very informative to explore further whether some forms of AIGAs had been promoted, and if it was the case, whether these AIGAs had been successful. The literature tells us that, in general, the success of AIGAs and AIGA projects depends on three factors: (i) the existence of efficient markets, (ii) qualitative and quantitative adaptation of supply to these markets, and (iii) a return of a substantial part of the generated benefits towards local populations. As pointed out by Garcia *et al*. (2013), the meeting of the first two conditions can often face various obstacles: local markets are not large, coastal communities are economically and infrastructurally isolated/marginalized, or they lack capacity to engage in the AIGAs. The third condition is not often well met in the case of tourism (Pascal, 2011). In addition, in some cases, these tourism activities generate negative socio-cultural and environmental impacts for local populations. It can even be a hindrance to conservation objectives, urging for example fishers to fish undersized fish or sea products in order to meet the demand of restaurant managers, as was observed concerning lobsters in Belize (King, 1997). It can also bring about tensions in local markets or conflicts relating to access to common resources (water, space, coast), as some studies in Madagascar suggest (Chaboud, Méral and Andrianambinina, 2004).

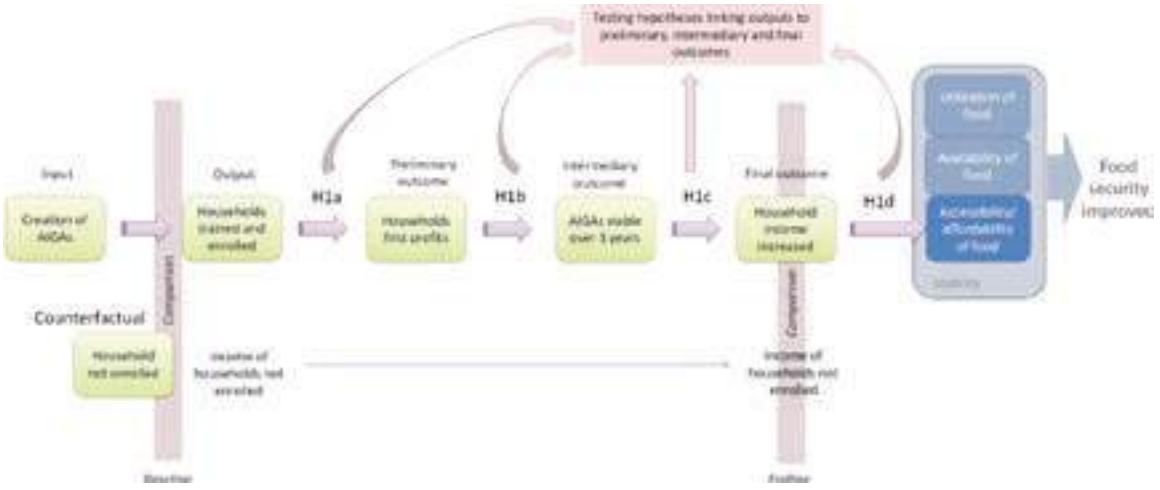
THEORY-BASED APPROACH

It is unlikely that the national-level data sets that Andam and his co-authors used for their analysis in Thailand and Costa Rica were detailed enough to allow them to test all these specific hypotheses. The point of the discussion is elsewhere, however. It illustrates the necessity to go beyond an input-output analysis, and instead to break down the links between the initial outputs and the final impacts into a series of hypotheses that can be tested along the different causal pathways. This approach derives directly from Theory-Based Impact Evaluation (TBIE) methods (Weiss, 1997; White, 2009; Rogers, 2009). The general idea behind the TBIE methods is to test the links in the causal chain of the Theory of Change of the programme under consideration and to gain an understanding on how contextual factors shape and influence the extent to which the theory explains the reality of the context in practice (Carvalho and White, 2004). That is, the TBIE is used to reveal the logic underlying the ToC, tracing the steps from inputs to final outcomes, and to identify the entry points where rigorous assessments of the links/hypotheses in the ToC can be conducted.

Figure 3 illustrates this process in the specific case of the income causal pathway discussed above. The diagram shows that a TBIE method would set up some form of baseline-endline around the key indicator(s) related to the causal pathways under consideration (in this specific case the households' incomes) and establish a counterfactual (in this case involving households that are not enrolled in AIGAs). However, in addition to this counterfactual test, the hypotheses at each step along the chain of events between outputs, preliminary, intermediary and final outcomes for changes to happen, are being tested. This process allows us to establish if indeed our initial ToC and the specific causal pathway we proposed are correct. If both the tests with the counterfactual and the different hypotheses along the pathway appear significant and in the sense (or with the sign) expected, then we can realistically

claim that the creation of AIGAs has contributed to the increase in incomes for the households who benefited from the AIGAs programme.

FIGURE 3
A theory-based impact evaluation (TBIE) approach applied to test the causal pathway between the creation of AIGAs and the increase in income of households benefiting from these AIGAs



Source: Author.

The TBIE has been gaining traction in the impact evaluation literature (see e.g. Weiss, 1995; White, 2009; Barnett and Gregorowski, 2013) and is starting to be applied in the context of conservation projects and even protected area projects, although more on the policy process side (see Pressey, Visconti and Ferraro, 2015). These various authors argue that when the process under consideration is a complex process underpinned by a multicomponents ToC, TBIE provides the most appropriate impact evaluation framework as it can reflect and account for this complexity (Weiss, 1998; Carvalho and White, 2004). It has been demonstrated in the first part of this second section why it is reasonable to claim that evaluating the potential impact of MPAs on the food security of local populations is a complex process underpinned by a complex ToC, and therefore why applying a TBIE approach is justified.

CONCLUSION

The underlying question of this paper concerned the potential impact of marine reserves on the level of food security of the populations living in or around these reserves and how to assess this impact. This question is particularly relevant given the renewed attention paid to the issue of food security in a context where many low-income and food-deficient countries have at the same time expressed their intention to expand the number of their protected areas in order to comply with the Convention on Biological Diversity.

Many state-of-the-art studies are available in the literature on the general ecological and social impacts of protected areas. The most rigorous ones highlight the general lack of consistency in the very limited evidence collected so far on the question of reserves in general and food security. Instead of producing (yet) another review of this limited information base, we proposed in this paper to push the discussion one step further and

to identify and discuss some of the reasons why the different parties involved in the discussion around reserves have failed so far to provide robust and consistent evidence on the link between reserves and food security.

In the first part of the subsequent analysis a discourse analysis was applied to the existing literature. The objective was to place the discussion back into the wider debate about conservation versus poverty alleviation, and to provide some potential explanation for the lack of consistent and rigorous assessments observed in the literature, while accounting for the wider context within which this specific debate is taking place. The analysis highlights that this absence of scientific rigour is not necessarily due to a lack of appreciation for basic monitoring and evaluation principles, but reflects instead the fact that the question of food security has been essentially treated from a rhetorical perspective in a large part of the literature, thus preventing a proper debate of the question. The narrative analysis also reveals how the attempts to reconcile conservation and fisheries management agendas lead to a progressively more "integrating" approach accounting for the fact that at global as well as national levels, the "no-reserves" option is not acceptable to conservation authorities which use reserves as a central instrument, just as "no-fisheries" is not an option for fisheries-dependent communities. This fact implicitly co-opts the fishing and conservation communities into a complex decision process calling for a compromise implying trade-offs, cost-benefits distributions and compensations, etc. By so doing, this process sidelines the most polemical claims from the radical sides of both fisheries and conservation. It may also have neglected addressing more forcefully one of the main narratives around reserves and local population: the positive and negative impact on food security in the short and long terms.

The second part of this paper revisits some of these questions from a more technical, impact evaluation perspective. A central element in this second part of our analysis was the building of the generic Theory of Change (ToC) that describes the multiple causal effects of reserves on food security (this methodology may, however, be applicable to a broader analysis of the impacts of MPAs, including other scenarios, in addition to marine reserves). This generic ToC is then used to illustrate why, even with a baseline/endline approach or a treatment/control protocol, the majority of the quasi-experimental approaches that have been proposed in the recent literature would still have difficulties to determine how and why a MPA/marine reserve does (or does not) contribute to improve the food security status of the local population living around that reserve. Our argument is that the causal pathways between the establishment of reserve (preliminary output) and the food security of the local population (impact) are multiple and complex, and impact simultaneously different dimensions of people's food security. The black-box approach which characterizes most of these analyses is not well designed to capture this complexity. Instead a more comprehensive approach based on TBIE techniques is required. These TBIE techniques which are now becoming increasingly used in the impact evaluation literature, especially in relation to complex causal pathways, represent a great opportunity for scholars and practitioners interested in the question of the impact of reserves, and more generally MPAs on the food security of the local population, to finally draw some robust conclusions. Considering the time and costs involved, particularly in complex social-ecological systems, TBIE could be promoted in areas with enough capacity, perhaps in an adaptive process of testing MPAs in fisheries and dependent communities, hoping that the improving understanding could be generally applied elsewhere in comparable settings.

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Interactions of marine protected areas with fishery livelihoods and food security: concluding discussion

INTRODUCTION

This paper seeks to draw insights from the collection of papers on fisheries, MPAs and other aquatic PAs, food security and livelihoods contained in this volume, as well as others presented at the World Parks Congress in Sydney in 2014. Some important conclusions emerge, or are confirmed, that are worth underlining as more attention is progressively focusing on the effects (positive and negative) of aquatic PAs on human well-being and, in particular, on livelihoods and food security of dependent communities. This is particularly the case for small-scale fishing communities, on which this volume is focused.

Sustainable livelihoods and food security are closely related for those in rural resource-dependent areas, as food security depends to a very large extent on the stability of livelihoods and their capacity to generate enough entitlements for a sufficient and stable access to food. This involves both short-term and long-term perspectives; for example, immediate losses in both livelihoods and food security might be argued as necessary to obtain longer-term benefits.

Similarly, food security among fishing households and in the broader community, is closely related. The more important fishing is within that broader community, the stronger is that relation.

During the last two decades, significant momentum has developed in international conservation arenas over the use of protected areas (PAs) (particularly marine protected areas, MPAs) in aquatic ecosystems. Many scientists argue the positive impacts of aquatic PAs on rebuilding and/or maintaining fisheries productivity, and the production of socio-economic as well as ecological benefits for the communities involved. This view has led to advocacy of MPAs as fishery management tools. However, within the fishery sector, there is a more mixed perspective. The positive impact of PAs on the biodiversity inside no-take areas (NTAs) has been convincingly demonstrated in many places. However, the impact on fishery resources outside NTAs (through larval and biomass spillover) and on fisheries economies depend on species and socio-economic contexts and have been hard to demonstrate. Nonetheless, progress is being made as improved baselines and monitoring systems are put in place (Goñi, 2011; Garcia, Boncoeur and Gascuel, 2013; Costello, 2014) Certainly, there is also empirical evidence of communities seeing these benefits, and not only accepting but also actively supporting aquatic PAs. However, a number of studies have also pointed to very slow or no obvious improvements in fishery resources, economic losses, increased risk, threats on livelihoods and violations of traditional and human rights (e.g. in the global review of Garcia, Boncoeur and Gascuel, 2013). These different

assessments reflect the two ends of a spectrum, with the report of the High Level Panel of Experts on Food Security concluding its large review of the matter by stating *inter alia* that no generalization was possible and that MPAs could have positive or negative effects depending on the context, i.e. the geography, initial ecological and socio-economic conditions, internal dynamics and external drivers associated with the protected area.

COMMON REALITIES

All the papers included in this volume address aquatic PAs located in coastal or inland areas that are relatively densely populated, and in which some communities are particularly vulnerable. In such settings, therefore, aquatic PAs interfere with traditional fishing patterns and have an effect (positive or negative) on nearby communities. This is a very different scenario from that of large offshore or high seas MPAs which, a priori, are seen as having a much less significant impact on food security or livelihoods of fishery-dependent communities. Within the context of coastal and inland areas, the following collective insights of the cases presented in this volume, and the broader PA literature, may be made:

1. Aquatic PAs should be seen as tools or means for ecosystem and natural resource protection and, if properly planned, as fisheries management instruments among other available measures, rather than an end in themselves. In other words, they should be judged on their performance in delivering the expected outcomes for society, not merely by their existence and expansion (Fletcher, this volume).
2. Measuring PA's performance on the well-being of their neighbouring populations remains a controversial issue, particularly in developing nations where vulnerable communities stand to be first and most affected in the short term. Part of the problem is in the inability of those proposing or opposing MPAs, to generate enough rigorous and robust evidence about the exact nature of the relation between conservation and human development because of methodological flaws in the respective analyses (Béné, this volume).
3. Human pressure on coastal ecosystems, in developing as well as developed countries, has increased dramatically in recent years through various factors, including population growth, migration towards coasts and inland water bodies, industrialization, growing market demand for aquatic products, and long-term deficiencies in governance of integrated space-based planning and fisheries, law enforcement, and resource management (Brenier and Vogel, this volume).
4. On the other hand, vulnerable or marginalized human populations that are wholly or largely dependent on aquatic resources for food and for providing purchasing power for other foods and staples will be adversely impacted in the short term by aquatic PAs restricting access to space and resources (Stacey *et al*., this volume). On the other hand, aquatic PAs designed and implemented in an appropriate manner may provide a vehicle for long-term livelihood and food security.
5. Depending on their design and performance, PAs may either aggravate or mitigate the impacts of the conventional laisser-faire policies usually applied to small-scale fisheries (involving the human pressures noted above) that are also adversely impacting fishing and coastal communities.
6. There is a general agreement in the aquatic PA literature, including the papers in this volume, that aquatic PAs established in populated areas are unlikely to be successful in meeting their conservation objectives if they do not also provide clear benefits to the communities concerned, particularly in terms of livelihoods and food security. The systematic resistance of fishers to the top-down introduction of aquatic PAs (Nurhidayah and Alam, this volume) reflects that principle.

7. Conventional fishery management, through gear control, access regulation, catch and effort limitations, zoning and allocation of fishing rights, also has significant socio-economic impacts which in many cases have also not been studied ex ante or formerly assessed ex post. There is, however, an evolution towards more participatory fisheries management through the application of the ecosystem approach to fisheries (EAF) and co-management, which could lead to more systematic and objective assessment of both fisheries management measures and MPAs.

CHALLENGES IN ASSESSING IMPACTS

Measuring impacts of PAs on coastal and fishers' communities requires two key ingredients. First, there must be a collection of socio-economic information within multiple-use MPAs and around no-take zones (NTZs) within the area affected by the introduction of the PA. Second, an analytical framework is needed, to identify cause-effect relationships (Béné, this volume). In this regard, the difficulties noted in the various papers of this volume regarding assessment of impacts include:

c. New issues. Poverty alleviation and food security as criteria for PA performance are rather new issues, as is the systematic analysis of performance concerning these factors. Very little information is available at present to make conclusions on the effect of PAs with regard to food security in marine fishery resource-dependent communities (Stacey *et al*., this volume).
d. Impact of other drivers. Environmental degradation is particularly important in inland aquatic systems and coastal areas; urbanization and industrialization threaten livelihoods and food security (and safety) of fishery dependent communities. Changes in the state of the economy in rural or peri-urban systems, in climate or markets, also impact the system and complicate the identification and measure of the additional impact of PAs (van der Ploeg *et al*.; Tsurita, Hori and Makino, this volume). The willingness to maintain lifestyles is sometimes considered as important a driver of attitudes as revenues (Johnstone *et al*., this volume), and cultural values (e.g. respect, spirituality and hospitality) may play a greater role in explaining attitudes than concerns over food security and livelihoods (van der Ploeg *et al*., this volume).
e. Monitoring. Suitable monitoring arrangements are essential to identify and interpret trends. The difficulty is in identifying the appropriate indicators reflecting human and ecological well-being that could be collected with the limited resources usually available. (Tsurita, Hori and Makino; and Béné, this volume).
f. Empirical evidence. Interpreting these indicators, when available, in terms of cause-effect relations is also a difficult undertaking, particularly in large and complex areas/ecosystems. The interpretation is also complicated by the fact that debates over aquatic PAs and fisheries tend to be highly sensitive and politicized, with a mixture of science and advocacy. These difficulties are compounded by the difficulty to adopt efficient experimental designs, particularly in large-scale complex systems of aquatic PAs (Fletcher, this volume).
g. Lack of ex ante and ex post assessments. In the large majority of aquatic PAs, there is a lack of ex ante assessment, explicitly accounting for the uncertainty (e.g. about the resources, the communities, their present condition, their potential reaction to the establishment of the PA, and the distribution of likely costs and benefits in space, in time and among the actors). One of the most significant consequences of this lack is the absence of baseline conditions against which to measure impacts, limiting the undertaking of any ex post assessment.

DRIVERS UNDERLYING INTERACTIONS OF PAS WITH LIVELIHOODS AND FOOD

SECURITY

Underlying the interactions of PAs with livelihoods and food security are certain key drivers that seem crucial to understanding, predicting and improving how those interactions take place. Five of these key drivers are highlighted here.

a. **Distribution of benefits.** The judgements made concerning the impact of PAs on people's livelihood and food security is closely connected to the relative distribution of costs and benefits (or perception of that distribution) and its equity (Nurhidayah and Alam, this volume). Experience shows that in the absence of suitable empowerment of fishers and communities, a large part of the benefits from PAs may be appropriated by actors from outside of the fishing and even coastal communities (particularly those related to tourism). Most papers agree that this may be the case especially if the capacity of these communities has not been appropriately developed, or could not be developed fast enough, to benefit from the new opportunities, which are then instead appropriated by better equipped actors (see for example Nurhidayah and Alam; and Orrego and Rodríguez, this volume).
b. **Dependence.** In many developing countries' rural areas, communities are very dependent on fisheries for revenues and food. This dependence implies that there are few other opportunities available and communities are particularly vulnerable to being harmed by encroachment on their traditional livelihoods. [In these contexts, alternative or complementary livelihoods will be necessary but, in the past, these have often been proven to be very difficult to maintain sustainably and must be addressed in a more culturally sensitive manner (Brenier and Vogel, this volume; Bennett *et al*., 2014).
c. **Fisheries dynamics.** The 40 years of history of the Banc d'Arguin marine park in Mauritania underlines the complexity of combining resource conservation and fisheries development objectives. As small-scale fisheries evolved from subsistence to commercial in a progressively globalizing market economy, some elements of the community increased profits, others incurred losses in livelihood. The reinvestments of the profits derived from management of this very large-scale MPA, in fisheries inside the MPA, led to perverse effects in terms of equity and conservation (Ly, this volume).
d. **Enforcement and compliance related to controls placed on gears, effort, access to areas and resources, catch limits and traceability of catches (Ly; and Orrego and Rodríguez, this volume) are often referred to as major issues in this volume.** This relates obviously to the means available to manage a fishery or PA and hence to sustainability of the resource, the fishery, the livelihoods and food supply, and the financing required. It also relates to a large extent to the attitude of the communities concerned and their degree of participation in decision-making and subsequent support of the PAs and the related regulations.
e. **Financing.** Long-term sources of financing are absolutely needed to sustain management of the fisheries and the PAs interacting with them (Brenier and Vogel, this volume). Project-based financing – particularly from external sources – has shown its limits. Management of small-scale fisheries have faced the same problem for decades. Self-financing (e.g. through tourism) has been shown elsewhere to be a solution if the risk of deflection of revenues away from the community can be contained.

MOVING FORWARD

The rich variety of case studies and analyses in this volume provides a sense of the wide range of outcomes that can arise in terms of the interactions of PAs with livelihoods and food security. On the one hand, some papers stress the significant resistance of fishers towards the placement of MPAs in their traditional fishing grounds (Nurhidayah and Alam, this volume), illustrating the negative perception of that instrument. One paper describes a significant immediate loss of total catch (30 percent) with no recovery after nine years, contrary to predictions (Fletcher, this volume). On the other hand, some papers indicate benefits of MPAs, such as maintaining the quality of freshwater areas for decades in the Philippines (van der Ploeg *et al*., this volume); rebuilding eel-grass habitats in Japan (Tsurita, Hori and Makino, this volume) with an assumed increase in ecological resilience, and increased social networks and spirit of cooperation (Tsurita, Hori and Makino; Orrego and Rodríguez; and Brenier and Vogel, this volume). In another case, a community's income has been increased through tourism related to the management of turtle nesting beaches (Orrego and Rodríguez, this volume). These benefits are encouraging to document despite inherent difficulties. In line with earlier comments on complexity, it is also stressed that results can be positive in some areas and negative in others (van der Ploeg *et al*., Johnstone *et al*., this volume).

None of the papers report directly on observed positive or negative impacts on livelihoods and food security, although Johnstone *et al*. (this volume) report on perceptions of such impacts in fishing communities. Somewhat tangentially, the long-term example in the Banc d'Arguin (Ly, this volume) points to the fact that without adequate foresight of potential perverse feedback loops, some positive impacts may not be sustainable as key conditions change inside and around the PA, a warning already given by Ostrom (2007) about dynamics of social-ecological systems.

Is it possible to increase the chances of success, and to produce greater net benefits for food security and livelihoods, resulting from PAs? The following approaches and actions may help to improve the outcomes for fishing communities from using PAs, in particular benefits in terms of livelihoods and food security:

a. **Adequate policies.** There is an urgent need to refine marine conservation and fisheries policy-making so that food security and poverty alleviation are seen as integral and complementary to conservation objectives. Such policies should, as appropriate, consider also the risk of overuse attached to sedentarization of migrant fishers' communities (Stacey *et al*., this volume; Garcia, Boncoeur and Gascuel, 2013).
b. **Clear objectives.** If PAs are to have positive impacts on both ecological and human well-being at a local scale, their planning should integrate both sets of objectives, explicitly (Nurhidayah and Alam, this volume). Historically, these objectives have rarely been considered together, and have, therefore, missed looking for synergies and avoiding conflicts and trade-offs. It should not be surprising, therefore, to discover that in PAs established for ecological protection, it is hard to find evidence of a positive impact on livelihoods and food security. The challenge is particularly acute in large and complex PAs, with varied systems of use of a mosaic of resources, in which success or failure needs to be assessed against a complex bundle of objectives and implicit expectations (Fletcher, this volume).
c. **Participation.** In all papers, a high level of effective participation is considered as a clear condition of success – seen as depending on both the degree of involvement (relating as well to suitable empowerment) and the commitment and support of stakeholders (including communities) in planning, implementation, monitoring and enforcement. This is compatible with the existing literature, which provides abundant illustrations of the failure of top-down governance and, in contrast, the improved performance resulting when the community is engaged. A good

demonstration of effective participation is the collaborative development of management plans which improves the "ownership" of the PA by the community (Orrego and Rodríguez, this volume). Participation is also stimulated through the use of fishers' knowledge and memory, particularly when data collection systems are not in place (Johnstone *et al*., this volume). Last but not least, the full support and leadership of the local authorities (van der Ploeg *et al*., this volume) and support from the other stakeholders in the community (Tsurita, Hori and Makino, this volume) is considered a key factor of success. The highest level of "participation" is probably shown by voluntary initiatives coming from the communities themselves (Tsurita, Hori and Makino, this volume) and these will benefit from the institutional and technical support from the state.

d. **Capacity-building.** Participation is necessary but not sufficient if the capacity to effectively participate is not developed. This is recognized particularly in multiuse MPAs and responsible marine fishing areas (RMFAs). Capacity-building is required in PA design: co-management structures; monitoring, control and surveillance; and adaptive management. Awareness-raising may contribute to this as well (Nurhidayah and Alam; Bystrom; and Brenier and Vogel, this volume).
e. **Management measures.** It is important to suitably combine PA management with fishery management (as promoted in FAO, 2011). The latter includes operational management measures (e.g. fishing zones, and effort and catch limits) – which may need to change dynamically – as well as structural (policy-level) measures, such as limited entry and fishing rights (Ly, this volume). The establishment of rights-based fishing is seen as positive in some communities, particularly if it helps to exclude "outsiders" (Nurhidayah and Alam; and Ly, this volume). Also relevant is community-based fishery management and conservation, within small-scale fishing communities. Equity in allocating rights of access is a very sensitive issue and particular attention must be given to vulnerable components of the community and particularly traditional migrants, often dispossessed of their traditional rights in favour of residents (Stacey *et al*., this volume). In areas of highly dynamic productivity (e.g. with strong seasonal and inter-annual variations in abundance and distribution), forced settling of traditional migrants into fixed locations may be a source of overfishing (Stacey *et al*., this volume). Framing these measures in an agreed and cooperatively developed management plan would improve compliance (Orrego and Rodríguez, this volume).
f. **Traditional knowledge** and the use of fishers' memories can be a substantial contribution to the success of PA design and implementation. The development of an historical perspective of the communities and their functioning helps in developing better understanding and prediction of the effects of a PA (Brenier and Vogel, this volume).
g. **Communication and knowledge.** A better understanding of how PAs interact with livelihoods and food security can be built through both the wise generation and application of knowledge, and strong and enduring communication mechanisms. Two mechanisms to accomplish this could be: (i) to develop a central database of information on MPAs, fisheries, food security and livelihoods (Fletcher, this volume) to facilitate research and understanding, and to improve foresight; and (ii) to develop better communication channels between villagers, local leaders, local government and NGOs, national authorities and international donors (van der Ploeg *et al*.; and Tsurita, Hori and Makino, this volume).
h. **Compensation.** Financial compensation has been seen as a positive means to alleviate some of the immediate costs of exclusion or displacement (Johnstone *et al*., this volume) of fishers from aquatic PAs. Alternative livelihoods and income-generating activities (ALIGAs) are needed to help compensate some of the short-term direct costs and opportunity costs resulting from the establishment of PAs

(Nurhidayah and Alam; and Ly, this volume). However, their outcomes are not always predictable or their evolution controllable. Therefore, planning needs to account for external drivers (Ly, this volume). Care has to be taken, however, to ensure that the compensation is not invested in additional fishing power, which would thereby operate as a perverse subsidy (contrary to conservation goals).

DISCUSSION

The set of papers compiled in this volume provides a rich sampling of the many practical situations in which PAs interact with fisheries, livelihoods and food security. The general advocacy on MPAs as fisheries management instruments has sometimes referred to a positive impact on fishers' livelihoods, but with little or no real information and analysis of the alleged impacts. This document, although not as comprehensive as systematic reviews undertaken by Charles and Sanders (2007), FAO (2007), Martin *et al*. (2007), Claudet (2011), Garcia, Boncoeur and Gascuel (2013) or Westlund (2014), is the first attempt to look at the impact of aquatic PAs in fisheries, specifically in relation to livelihoods and food security. These two important issues have not been part of the core concern of protected areas, so the lack of information on them, in a PA and fishery context, is understandable. However, the increasing interest around them will lead to increased research attention – and increased insights, provided that baselines, data collection systems and experimental designs are improved.

As has been highlighted in other fora, and notably the 3rd International Marine Protected Areas Congress (IMPAC 3) in Marseille, in October 2013 (Westlund, 2014), a central message and key lesson for conservation and sustainable use is that the active support of the vulnerable and dependent fishing communities in the process of integrating PAs into fisheries management systems may well make the difference between success and failure in meeting conservation objectives (cf. Charles *et al*, 2016 among many others). That condition, while perhaps not sufficient, does appear as necessary. Evidence abounds that conservation initiatives, without clear socio-economic objectives, and imposed without fishers and community support and involvement, tend to systematically fail. The greatest opportunities for success come when this support and participation is combined with comprehensive attention to the human dimensions underlying threats to livelihoods, food security and environmental sustainability (Charles *et al*., 2016).

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