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Explicitly incorporating socioeconomic criteria and data into marine protected area zoning

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A B S T R A C T

Addressing community needs or aspirations is critical for the success of marine protected areas (MPAs). However MPA design based on the results of systematic conservation planning tools alone does not fully represent important information on socioeconomic factors. This is because of the reliance of conservation planning tools on spatial data which is better suited to ecological rather than socioeconomic factors which are predominantly non-spatial. We present a case study from Raja Ampat in Indonesia, to demonstrate how we developed MPA zoning plans for six multiple use MPAs that encompass more than 1 million ha of the world's most diverse coral reef ecosystems. These were developed by combining analysis of ecological and spatial socioeconomic data using decision support tools (Marzone), and incorporation of non-spatial socioeconomic data from experts, stakeholders, and local communities. By explicitly including socioeconomic criteria and data into MPA zoning, the final zoning plans recognize community use and governance of resources, maximize equity and access to traditional fishing grounds, and better support long-term food security and livelihoods of local communities. These plans also met recommended guidelines for resilient MPA design and were supported by the community and MPA managers (i.e. Raja Ampat Regency and Indonesian National Government). This case study can act as a guide to other MPA managers and conservation practitioners to better incorporate socioeconomic considerations into MPA zoning plans and systematic marine conservation planning.

1. Introduction

Overexploitation of coastal resources is causing irrevocable changes to the structure and function of our coasts and oceans (Halpern et al., 2008; Burke et al., 2011). Integrated forms of governance and management that incorporate ecological, economic, social and governance factors are essential to effectively resolve issues of unsustainable use.

Ecosystem based management (EBM) is an approach that includes humans and society as part of the ecosystem and therefore considers social, cultural, economic and ecological factors in the development of management solutions (Arkema et al., 2006; Curtin and Prellezo, 2010). Marine Protected Areas (MPAs) and MPA networks are important outcomes of an EBM approach to marine spatial planning (MSP) (Katsanevakis et al., 2011) and are one of the most cited management tools to conserve marine biodiversity, habitats and ecosystem services (Lubchenco et al., 2003; McCook et al., 2010; Green et al., 2014). MPAs are one of the key strategies for conservation and sustainable fisheries in the Coral Triangle (CTI Sectretariat, 2009). The Government of Indonesia has demonstrated its commitment to establishing a regional network of MPAs through its leadership in the Coral Triangle Initiative (http://www.cti-secretariat.net/).

However, in most parts of the Coral Triangle, the effectiveness of MPAs and MPA networks is low (White et al., 2014) due to a lack of local community or government awareness, support or capacity to enforce zones and regulations. Increasingly, managers and scientists are recognizing the importance of socioeconomic factors to the successful implementation of an MPA. Uses and activities in an MPA are usually regulated through a spatial plan known as an MPA zoning plan that identifies the location and definition of multiple

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zones (Friedlander et al., 2003; Richardson et al., 2006; Cinner, 2007; Ban et al., 2013). In particular the perceptions and aspirations of the beneficiaries of conservation and development must be recognized and incorporated into the final zoning plan. Existing novel approaches to incorporate socioeconomic factors into spatial planning include: integrating economic factors or costs (Naidoo et al., 2006; Wilson et al., 2007; Arponen et al., 2010); mapping traditional use and social assets (Aswani and Lauer, 2006; del Campo and Wali, 2007); integrating data on social institutions and governance structures (Pressey and Bottrill, 2008; Mills et al., 2013); and measuring social well-being indicators (Stephenson and Mascia, 2014).

Existing tools used to support the development of MPA zoning plans are designed to analyze spatial data by setting quantitative targets for representation. While these tools were originally designed to analyse biological and ecological factors, they are now being used to incorporate socioeconomic factors (e.g. Grantham et al., 2013). However, socioeconomic data are not always easily represented spatially (St. Martin and Hall-Arber, 2008; Ban et al., 2013) and concepts such as equity do not lend themselves to simple quantitative targets especially in hierarchical societies. In many cases of MPA zoning, socioeconomic factors are described in vague terms (e.g. minimize impact on livelihoods) (e.g. Fernandez et al., 2005). Social interests are more often treated as threats (Pressey et al., 2007; Stephanson and Mascia, 2014), rather than as specific objectives for MSP (Fernandez et al., 2005).

We found little published information on how to combine spatial and non-spatial data related to socioeconomic factors in the development of an MPA zoning plan.

We present a case study from Raja Ampat in Indonesia, to demonstrate how we developed MPA zoning plans for six multiple use MPAs that encompass >1 million ha of the world's most diverse coral reef ecosystems using an EBM approach. We used ecological and spatial socioeconomic data in decision support tools for spatial planning (Marzone), and non-spatial socio-economic data from experts, stakeholders, and local communities to produce MPA zoning plans. These plans met recommended guidelines for resilient MPA design and were supported by the community and MPA managers (i.e. Raja Ampat Regency and Indonesian National Government). This case study can be used as a guide for other MPA managers and conservation practitioners to better incorporate socioeconomic considerations into MPA zoning plans and systematic marine conservation planning.

1.1. Site description

The Raja Ampat Regency off the northwestern tip of West Papua in eastern Indonesia encompassing 4.5 million ha of ocean, islands and coral reefs is a global priority for conservation (Mangubhai et al., 2012). Sitting in the heart of the Coral Triangle, Raja Ampat has the highest diversity of corals and reef fish on the planet (Veron et al., 2009). These ecosystems support more than 45,000[2] people who are highly dependent on the health and abundance of natural resources for food and livelihoods (Larsen et al., 2015). This area is now an internationally renowned dive destination with potential to bring income to local communities through a regency dive tag system and small scale businesses associated with the tourism industry (Mangubhai et al., 2012).

In West Papua, tenure over both land and marine areas is supported by the 2001 Special Autonomy Law. Traditional natural resource management known as 'sasi' that sets restrictions on harvesting certain species at particular times and locations is still practiced (McLeod et al., 2009a; Boli et al., 2014). Despite the diversity and abundance of resources and these customary forms of management, West Papuans are among the poorest communities in Indonesia. This is driving strong pressure for rapid, large-scale development to reduce poverty in West Papua. However, West Papuan communities rely on subsistence fisheries as a key source of protein (Larsen et al., 2015). Therefore increasing exploitation of natural resources, both legal and illegal, and irresponsible development practices threaten the health of coastal ecosystems and local fisheries (Mangubhai et al., 2012) and the food security of local communities.

In 2006, local communities initiated the establishment of a network of six multiple use MPAs covering 1,185,940 ha of coral reefs and small islands (Fig. 1) and zoning plans were developed with the support of The Nature Conservancy and Conservation International. In Indonesia, decentralized governance means that regencies may legally establish protected areas under parliamentary decrees, as long as they do not conflict with national laws.

2. Incorporating socio-economic factors into MPA zoning – a case study

The process of incorporating socio-economic factors in the development of multiple use MPA zoning plans for the Raja Ampat MPA network involved 1) setting objectives for the MPA network and developing biological and socioeconomic MPA design criteria, 2) collation and collection of spatial (Grantham et al., 2013) and non-spatial data, 3) the development of zoning scenarios using a decision support tool Marzone (Grantham et al., 2013), 4) modification of zoning scenarios to take account of non-spatial socio-economic data and 5) multiple reviews of draft zoning plans by stakeholders (Fig 2). Local government, local communities and other stakeholders provided input throughout this zoning process.

2.1. Setting objectives and MPA design criteria

The development of biological objectives and criteria is detailed in Grantham et al. (2013). Biological criteria took into account important biophysical characteristics of the region, as well as climate change-related resilience principles detailed in the scientific literature (McLeod et al., 2009b; Green et al., 2009).

Socioeconomic objectives for the MPA network were developed by government, communities and other stakeholders in Raja Ampat. The objectives are (i) support and promote sustainable livelihoods and the sustainable growth that results in a healthy marine ecosystems and food security and increased public welfare; and (ii) supply and preserve local knowledge, values and resource use systems (such as sasi) through the management of the MPA network.

We then developed 14 design criteria in consultation with local communities to meet these socio-economic objectives (Table 1). These criteria had the same status as biological MPA design criteria (detailed in Grantham et al., 2013). For each socioeconomic criterion, stakeholders assessed whether it was critical for zoning, local support and engagement in implementation of the MPA. Meaning, if a criterion was not met or addressed adequately, stakeholder buy-in or support would not be forthcoming. For example, improved fisheries and greater food security were considered critical, as these are the main motivation for communities to protect or manage land and coastal waters. This was an important process for setting targets used in decision support tools (see below). Equally zoning criteria were designed to reinforce or strengthen local communities' rights to utilize and manage their natural resources (Table 2).

[2] 2012 Census of residents, Raja Ampat Regency.

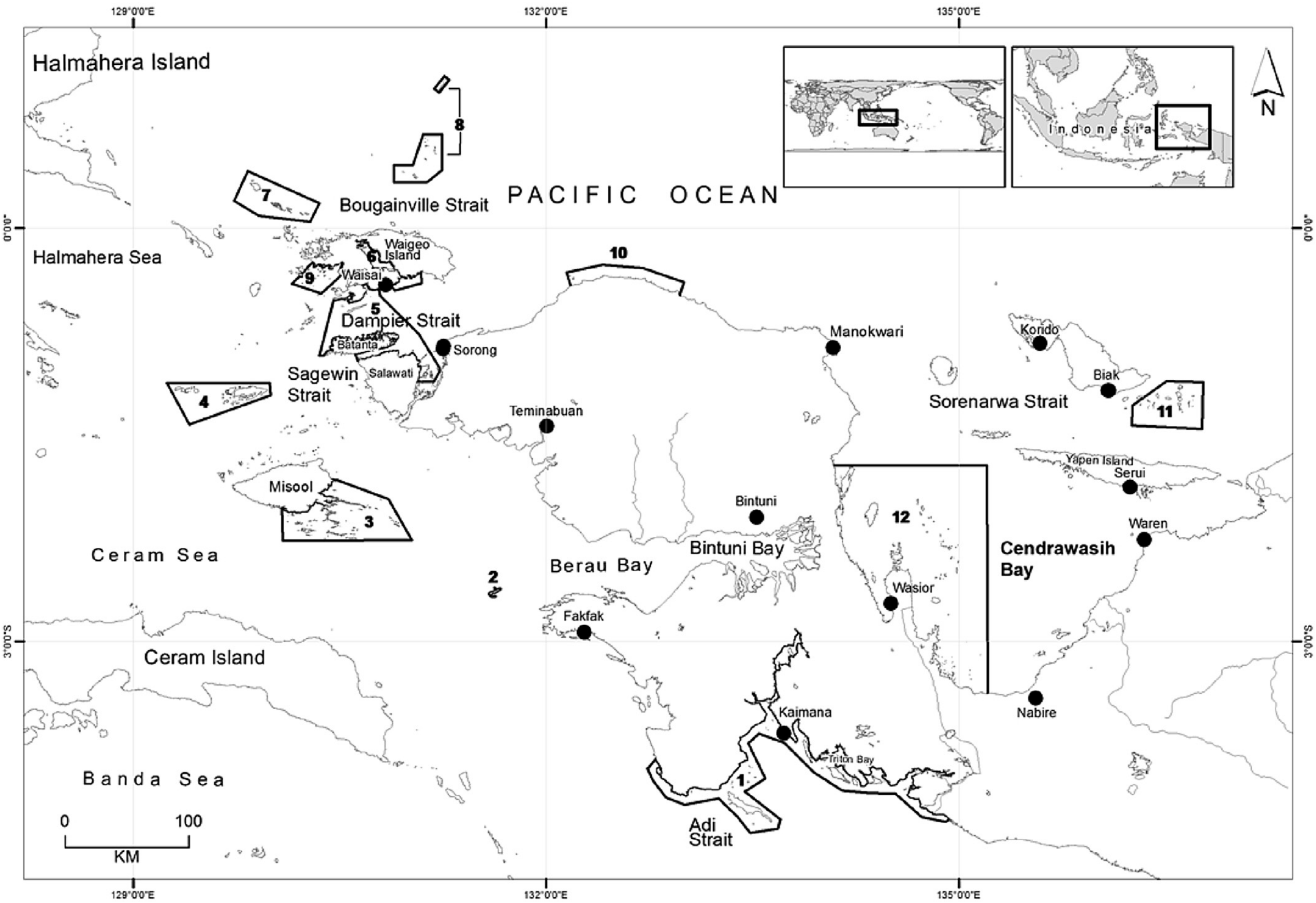

Fig. 1. Map of the Bird's Head Seascape showing the location of major towns, islands, and regency and marine protected area (MPA) boundaries. MPAs shown are: 1 = Kaimana, 2 = Sabuda Tataruga, 3 = Southeast Misool (343,200 ha), 4 = Kofiau and Boo Islands (170,000 ha), 5 = Dampier Strait (303,200 ha), 6 = Mayalibit Bay (53,100 ha), 7 = Kawe (155,000 ha), 8 = Ayau-Asia Islands (101,440 ha), 9 = Panjang Islands (previously West Waigeo), 10 = Abun, 11 = Padaido, 12 = Cendrawasih Bay. Sizes of MPAs are provided for those located within the Raja Ampat Regency.

2.2. Collation and collection of spatial and non-spatial socioeconomic data

Once the socioeconomic criteria were agreed upon, we developed a list of the data sets needed to support the inclusion of these criteria in the final MPA network zoning design (Table 1). Data and information that could be represented spatially (e.g. tenure boundaries) were termed spatial data while factors that could not be represented on a map were termed non-spatial data. Spatial and non-spatial data sets were obtained from field surveys of resource users (Muhajir et al., 2013a, b; Hess et al., 2011; Larsen et al., 2015; Leisher et al., 2012), interviews with households, government databases or documents and through interviews and workshops with stakeholders or appropriate community representatives. Data were housed in a GIS database developed specifically for Raja Ampat (Grantham et al., 2013).

2.2.1. Spatial data

The three most important spatial socioeconomic datasets for zoning were land and sea tenure, subsistence and artisanal fishing grounds, and community designed zoning plans (Table 1).

Understanding the nature and role of traditional tenure systems is fundamental in West Papua, and is often more important in the daily lives of local communities than provincial or national laws governing resource use. Land and sea tenure is not written into formal law, but passed on verbally from one generation to another with resource rights vested in individuals, families, clans or entire communities (McLeod et al., 2009a). We invested heavily in the mapping of traditional coastal and marine tenure through a series of focal group discussions, and identified areas with little conflict, or where protection could help reduce existing community conflicts.

Fisheries data from resource use surveys (Muhajir et al., 2013a, b) provided information on the spatial and temporal distribution of fishing type and effort, and the location and scale of illegal fishing activities (see detailed explanation in Grantham et al., 2013). It was also used to reconcile perceptions of resource use (Hess et al., 2011; Leisher et al., 2012) with actual resource use (Muhajir et al., 2013a, b), and ground-truth tenure arrangements.

Communities also developed their own versions of zoning plans based on discussions within villages on what might be suitable places for different zones (Grantham et al., 2013). The main zones that were considered were: (i) no-take, (ii) traditional use and sasi (where subsistence fisheries and traditional practices could occur), (iii) sustainable fisheries (where aquaculture and other commercial fisheries can be licensed), and (iv) transportation (mainly for demarking shipping lanes).

The visual display of socioeconomic data gathered through monitoring helped with discussions and negotiations for the placement and size of different zones with local communities, and

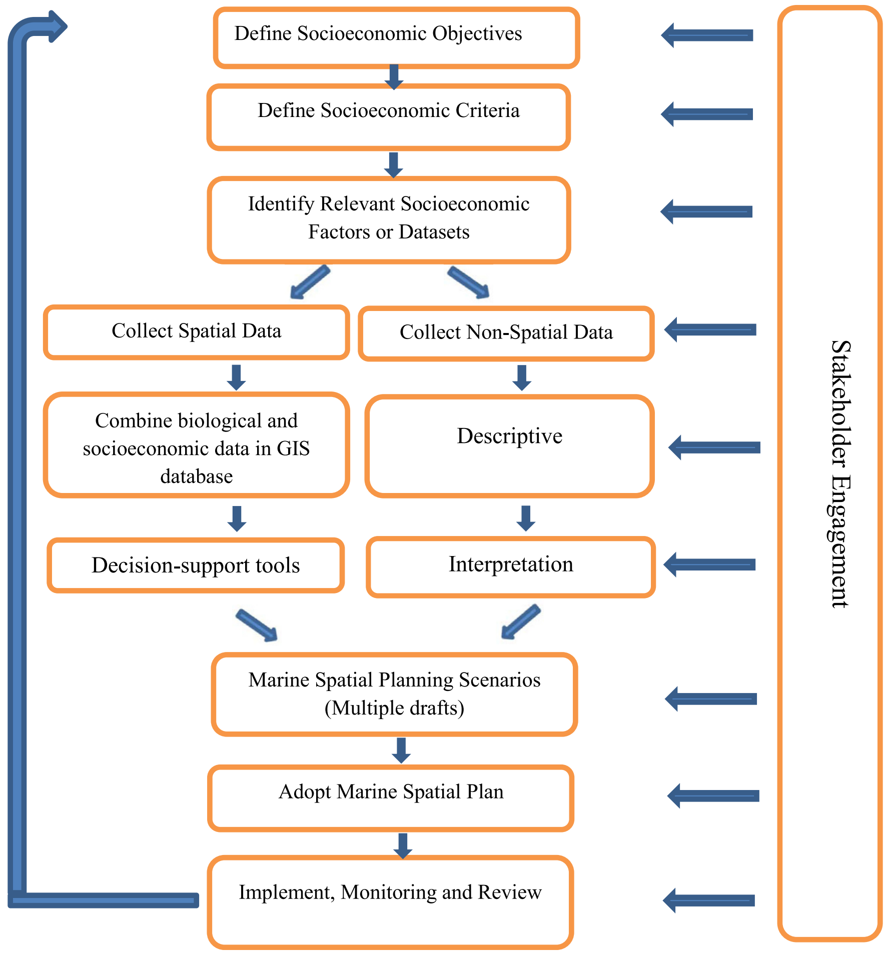

Fig. 2. Steps taken in the Raja Ampat case study to incorporate socioeconomic objectives and criteria into MPA design.

enabled modifications of their early version of a zoning plan.

2.2.2. Non-spatial data

We collected non-spatial data on community well-being (e.g. material assets, livelihood options, political empowerment, education, culture) as well as other factors (Table 1) that might affect the support for the MPA and compliance with zones and regulations. Socioeconomic datasets that strongly influenced the MPA zoning process in Raja Ampat were equity, community perceptions, traditional knowledge and management practices, and enforcement.

2.3. Decision support tools

Grantham et al. (2013) describes how we used the decision support tool Marzone to generate zoning scenarios for the Raja Ampat MPA network to meet multiple objectives based on biological, fisheries and spatial socioeconomic data. Briefly, we generated a series of zoning scenarios to identify areas important for biodiversity protection and for sustainable fishing, to achieve both biological and socioeconomic targets in MPA zoning design and taking into account community proposed zoning plans (Grantham et al., 2013). The zoning scenarios were reviewed by key stakeholders and local experts before being discussed and modified during community consultations.

2.4. Modification of zoning scenarios to take account of non-spatial data

Zoning scenarios produced by Marzone were modified with input from non-spatial data sets. Equity was particularly important in Raja Ampat where tenure rights occurred at the individual, family, clan, and/or village level, and differed across the regency. Focal group discussions focused on local tenure arrangements around areas proposed as no-take zones because this zone type restricts access to fishery resources and therefore has most influence on costs or benefits of zoning. Boundaries were then 'fine-tuned' to ensure costs and benefits were distributed equitably to the greatest extent possible.

Data collected during perception monitoring provided information on community attitudes towards protected areas, knowledge of the condition of natural resources, understanding of fisheries regulations, as well as changes in communities' reliance on marine resources for income (Hess et al., 2011; Leisher et al., 2012). Data collected on the 'willingness to contribute' to conservation and engage in the zoning process influenced the size and scale of community no-take zones. The level of commitment in turn influenced the amount of investment made to engage a village in zoning, and how best to tailor outreach strategies.

MPAs were delineated to align with customary tenure boundaries rather than solely administrative ones, in order to reinforce traditional tenure rights. A 'traditional use and sasi zone' was created to recognize traditional West Papuan practices of resource

Table 1
Socioeconomic objectives and criteria used to address objective 1 (to support and promote sustainable livelihoods and the sustainable growth that results in a healthy marine ecosystems and food security and increased public welfare) in the development of zoning plans for the Raja Ampat Marine Protected Area network. S = spatial dataset, NS = non-spatial dataset.

Criteria	Data set	S/NS	How it was incorporated in zoning
Allow for current and future multiple uses, including sustainable fishing, tourism, aquaculture, education and research.	Identify a range of zones, their purpose and permitted uses	NS	Design zone types to meet existing and potential future uses, address threats and align with community input and Indonesian law
	Identify existing and potential future uses in the MPA and surrounding area	S/NS	
	Identify threats and their relative impact	S/NS	
Incorporate government development plans, including land use zoning.	Governance boundaries (Sub-districts)	S	Used to ensure where possible, equity contributions from different sub-districts
	Regency and provincial spatial plans	S	Reviewed draft Regency and Provincial spatial plans to ensure MPA zone types were compatible with spatial plan zones, and development plans
Minimize negative impacts on existing local livelihoods. Maximizing opportunities for alternative incomes for local communities from sustainable uses.	Location and extent of all uses of land, reefs and ocean (e.g. towns, logging, plantation, agriculture, mangrove harvesting, pearl farms, resorts, artisanal fishing, industrial fishing, shipping lanes and other government or private infrastructure)	S	Design zoning so it did not conflict with existing (sustainable) uses by prohibiting that activity or restricting access or use.
Minimize conflict among users	Community development aspirations incorporated into the final zoning plan	NS	Design zoning so it did not restrict (sustainable) future uses identified by the community (e.g. options for future fisheries and tourism incorporated in zoning and regulations)
	Spatial and temporal patterns of existing marine resource use by local and 'outsider' fishers	S	Targets set in zoning analysis to protect subsistence fisheries (in use zones) and minimize impacts to local fishers. Designing zoning to reduce the likelihood of outside fishers coming in to fish (e.g. large portions of the MPA designated as no-take and for traditional use only, and restricting fishing gear types used by outside fishers)
	All current and potential future dive tourism sites mapped	S	Targets set in zoning analysis to protect dive tourism sites (in no-take zones) and therefore avoid overlaps between conflicting uses
Support sustainable subsistence fisheries to improve food security in the medium- to long-term	Gear type and target species documented for sustainable subsistence fisheries	NS	Zones designed to support subsistence (artisanal) fisheries Regulations developed on permitted and prohibited gear types
	Location and extent of subsistence (artisanal) fishing grounds mapped	S	Targets set in decision support tool to protect subsistence fisheries (in use zones), and prioritize subsistence fishing grounds as identified by local communities. No-take zones located adjacent to zones allowing subsistence fishing to maximize benefits from spillover effects
Allow for artisanal commercial fisheries	Gear type and target species documented for sustainable artisanal fisheries	NS	Regulations developed on permitted and prohibited gear types
	Location and extent of artisanal commercial fishing grounds mapped	S	Targets set in decision support tool to protect small scale artisanal fisheries (in use zones), and prioritize artisanal fisheries identified by local communities (e.g. sea cucumber, Trochus) No-take zones located adjacent to zones allowing for small scale artisanal fishing to maximize benefits from spillover effects
Give special consideration to species vulnerable to over-exploitation	Spawning aggregation sites, turtle nesting beaches and shark nursery or aggregation sites mapped	S	Targets set in decision support tool to protect key sites from threats
Maximize compliance with and ease of enforcement of zoning regulations	Enabling factors identified (i.e. distance from enforcement resources to highly protected zones, location of villages with community patrols)	NS	Modify zoning plan to support compliance and enable cost and time efficient enforcement
	Identification of industry partners that could assist with enforcement or act as a deterrent.	NS	Placement of no-take zones in areas frequented by dive live aboard vessels, or near pearl farms with armed security
	Community awareness of and attitudes to MPAs, conservation, natural resources, fisheries laws, etc. gathered through repeated perception surveys	NS	Materials for community consultation tailored to address individual communities level of knowledge and issues
	Willingness of communities to contribute to conservation, gathered through repeated perception surveys	NS	Zoning plan designed to reduce conflict with communities not supportive of conservation

management, strengthen existing rights of local resource owners to manage their resources, and provide legal recognition of these rights. The inclusion of traditional management practices generated greater community buy-in on zoning plans and afforded an opportunity to revive cultural practices that had been lost or degraded due to a breakdown in community governance.

2.5. Multiple reviews of draft zoning plans by stakeholders

The zoning plans underwent numerous reviews with stakeholders, especially local communities with strong tenure rights over land and sea. Consultation occurred at all levels of the community to ensure there was understanding of the zoning plan, and consensus across groups (e.g. youth, women, religious leaders, traditional leaders, etc.), to ensure maximum compliance with the final plan. During these consultations efforts were made to include all forms of traditional management into the final management plans, and build real ownership of the final plan. At the same time, the Raja Ampat Department of Fisheries was consulted and kept informed of the zoning process. They provided input on the names and types of zones and the activities permitted or prohibited within different zone types, to ensure consistency with Indonesian law

Table 2
Socioeconomic objectives and criteria used to address objective 2 (supply and preserve local knowledge, values and resource use systems (such as sasi) through the management of the MPA network) in the development of zoning plans for the Raja Ampat Marine Protected Area network. S = spatial dataset, NS = non-spatial dataset.

Criteria	Data set	S/NS	How it was incorporated in zoning
Incorporate traditional knowledge and conservation and sustainable fisheries practices	Identify sasi species and rules for harvesting	NS	Development of zone definitions
	Location and extent of sasi areas mapped and ranked	S	Areas allocated appropriate zone type Targets set in decision support tool to protect sasi areas (in 'sasi' zones),
	Traditional knowledge of marine resources	NS/S	Knowledge used the guide consultations or map spatial and temporal patterns of key fish and invertebrate species
Protect areas of cultural importance to communities	Location and extent of areas of cultural significance (e.g. sacred sites)	S	Areas placed in appropriate zone type, to protect these areas
Recognize, respect and incorporate Papuan marine tenure and local communities' rights	Maps of broadscale land and sea tenure and access rights obtained through focal group discussions and confirmed through resource use monitoring.	S	Areas using by different villages identified, and used to inform the location and size of zones
Ensure local resource owners remain central in decision-making processes.	Communities developed their own zoning plan, based on local knowledge of their MPA	S	Zoning solution from Marzone modified to align with proposed community zoning
Ensure both costs and benefits from marine protected areas are fairly and equitably distributed between communities (to the greatest extent possible).	Fine scale tenure boundaries and arrangements, obtained through focal group discussions and individual consultations	NS	Through focus group discussions, boundaries of no-take zones reviewed, and adjusted around an understanding of fine scale tenure arrangements to take into account equity and loss of access at a finer level (e.g. between individuals, family, clans, etc.)

and across the Raja Ampat MPA network.

3. Formalising and implementing the MPA zoning plans

Once the government and communities agreed to the final zoning plans, a traditional ceremony was held at each of the six MPAs to symbolise their commitment to protecting and co-managing the MPA, sustainably. The final management plan for the Raja Ampat MPA network was gazetted in 2013 under a Raja Ampat Regency Decree. A single management plan for the MPA network supports management of the MPAs as an ecologically connected representative network.

3.1. Community support for zoning

In the case of Raja Ampat, we found a growing body of evidence demonstrating community involvement in and support for their MPAs. Firstly, over 100 traditional management areas were declared by communities to improve invertebrate and fish populations inside MPAs. Secondly, public events held to declare zoning plans in six MPAs combined both traditional ceremonies and formal government procedures. These events symbolized both communities' and regency government's commitments to the MPAs and the adoption of zoning plans. Enforcement data showed communities within MPAs have a much higher compliance with fisheries regulations than outsiders (TNC, unpublished data). Thirdly, communities in some MPAs reinforced the zoning plan regulations by creating village regulations (*Peraturan Kampung*) that are recognized under Indonesian law. Village regulations can be enforced by traditional leaders and offenders can be prosecuted through the legal judicial system and/or the traditional system within villages.

3.2. Measuring progress

The World Bank Scorecard was used to provide a rapid assessment technique to keep track of progress towards the establishment and implementation of the MPA network (World Bank, 2004). Secondly, a 'traffic light system' with 16 socioeconomic indicators was developed with MPA experts and social scientists to measure progress towards MPA socioeconomic objectives (Supplementary Information). Many of the indicators built upon existing long term monitoring programs that were designed to assess the impact of zoning e.g. measures of coral health and fish biomass in different zones. The results of these formal monitoring and evaluation frameworks were used to modify annual work plans and investments within individual MPAs.

4. Discussion

The critical influence of socioeconomic and cultural factors on the success of MPAs must be recognized. In order for conservation efforts to work, they need to support sustainable development aspirations of local people and their governments. The Raja Ampat case study demonstrates how to incorporate an EBM approach including non-spatial socioeconomic factors to MPA zoning.

There are a number of important differences in conservation planning between developed versus developing countries. There are differences in socioeconomic, cultural and legislative contexts, as well as differences in the way people/communities interact with, and are directly dependent on nature for basic life functions (Abrams et al., 2009; Ban et al., 2009). Rapid human growth and increased poverty in developing countries makes it imperative to consider how any management action to achieve conservation of natural resources will affect basic human needs and survival (Chan et al., 2007; Abrams et al., 2009). Conservation can often be in conflict with community or government development goals and aspirations, especially if local and national economies rely heavily on revenues generated by the harvesting and exploitation of natural resources (Newton et al., 2007; Cheung and Sumaila, 2008). Under these socioeconomic conditions utilitarian arguments for conservation fail to resonate with communities (Chan et al., 2007; Miller et al., 2011) and lead to lack of compliance with zoning and regulations.

In the case of Raja Ampat, socioeconomic considerations had a strong influence on the declaration of the MPA network and the design of the final zoning plans. Socioeconomic data improved spatial configurations of zones to achieve socioeconomic objectives, but also influenced the types of activities allowed in each zone. Through the consultation process the community came to understand the global importance of the regions biodiversity and the potenital for eco-tourism which improved their understanding of the tradeoffs as they suggested changes to the size, location and boundaries of zones in the MPA. Communities were generally more receptive to adjustments to zones once their primary socioeconomic criteria and considerations were addressed. This generated a greater sense of environmental stewardship and communities were then more open to identifying no take zones and adopting more sustainable harvesting practices. Similar findings were recorded in Roviana and Vonavona lagoons in New Georgia, Solomon Islands (Aswani and Lauer, 2006).

The case study from Raja Ampat demonstrates that an EBM approach to MPA zoning that takes into account social, cultural and economic will likely have more community buy in, and support during its implementation. The case study detailed in this paper can help guide managers and conservation practitioners incorporate socioeconomic factors into conservation planning.

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Appendix A. Supplementary data

Supplementary data (Socioeconomic outcome indicators or 'traffic lights' developed for Raja Ampat MPA network) related to this article can be found at http://dx.doi.org/10.1016/j.ocecoaman.2015.08.018.

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