Maximising potential impact of Marine Protected Area placement: an integrated socioeconomic perspective.

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Contributions

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Abstract

Globally, Marine Protected Areas (MPAs) are one of the most widely used approaches to conservation and marine spatial management. MPAs are not, however, always placed in locations where they are most likely to maximise benefits to ecosystems and livelihoods. Current MPA guidelines fall short in that they focus primarily on biophysical criteria for benefits, with less consideration of interrelated socioeconomic factors. A contributing reason for this is the absence of an established, standardised set of socioeconomic factors to support decisions concerning conservation planning and MPA placement. This thesis aims to identify the socioeconomic factors that influence the effectiveness of MPAs, investigate ways to incorporate them spatially into MPA planning, and examine the role of these factors at national- and local-scales. The appropriateness of MPAs as tools for supporting marine ecosystems and associated livelihoods in some socioeconomic contexts is also explored. MPA effectiveness was defined in terms of 'impact', with impact being the outcome that arises from protection compared to the counterfactual scenario of no protection. The research was guided by four objectives: 1) to identify the spatially explicit socioeconomic factors that most influence MPA impact; 2) to develop and apply national-level socioeconomic indices that will help to determine where large-scale MPAs are most likely to be effective; at a local scale, 3) to understand how village heterogeneity influences the capability of fishers to adapt to MPAs; and 4) to design a systematic and spatially explicit method to identify those individuals most vulnerable to being negatively impacted by MPAs. The first objective was achieved via a systematic review of ten years of scientific literature on the socioeconomic factors that can influence how MPAs impact on ecosystems and livelihoods. This review resulted in a list of 32 factors that influenced MPA impact. To fulfil the second objective, a selection of these were populated with publicly available, national-level datasets, and principle component analysis was used to develop two national-level indices that represent potential opportunities and challenges for large-scale MPAs in low-income and developing states. The research applied a case-study approach to achieve the final two objectives, by characterising three poorly-documented small-scale fishing communities in Myanmar's Myeik Archipelago. Fieldwork took place over two months, and data were collected using surveys and participatory mapping with mobile fishers. Non-parametric and descriptive statistics were used to explore how variations among ethnic groups influenced fishing practices, and levels of vulnerability to MPA related changes. Finally, a composite analysis on four local-level socioeconomic factors was used to generate a Livelihood Impact Potential Index (LIPI) that describes the degree to which a fisher might be vulnerable to MPA-related restrictions on their livelihoods. ArcGIS was used to attribute to each fisher's LIPI score to their associated fishing grounds to spatially identify areas that would be most detrimental to fishers if they were restricted from fishing there. Results from this research help to fill the gap in MPA literature regarding the socioeconomic dimensions of

MPA planning, and can support MPA practitioners develop MPAs that maximise ecosystem and livelihood benefits from a national to local level.

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List of Acronyms

CITES	the Convention on International Trade of Endangered Species and Wild Fauna and Flora
EEZ	Exclusive Economic Zone
EIS	Evidence for Impact Score
EVI	Economic Vulnerability Index
GDP	Gross Domestic Product
HDI	Human Development Index
LIPI	Livelihood Impact Potential Index
LMMA	Locally Managed Marine Area
LSMPA	Large Scale Marine Protected Area
MNP	Marine National Park
MPA	Marine Protected Area
MSL	Material Style of Life
NMP	National Marine Park
NRSMPA	National Representative System of Marine Protected Areas
OEIS	Overall Evidence for Impact Score
SLMPA	Shark Large Marine Protected Area

Chapter One. Introduction

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Background

Marine ecosystems are important for a wide range of reasons, from maintaining biodiversity, to the fisheries they support, the tourism they generate and the protection of global climatic systems they provide (Sala and Knowlton 2006, Finegold 2009, Coker 2014). Despite the value of these systems, marine biodiversity and the ecosystem services they provide are being lost at an unprecedented rate (Sala and Knowlton 2006, Ceballos et al. 2015). As global population increases, so does pressure on natural fisheries (Finegold 2009), illustrated by rapid decline in global fish production since the late 1980s (Pauly et al. 1998). Overexploitation of marine resources has resulted in adverse ecological consequences (Pauly et al. 1998, Cinner and McClanahan 2006, Januchowski-Hartley et al. 2015), and subsequent negative impacts on coastal communities across the globe who rely on the natural wealth of the sea for their livelihoods (Clausen and York 2008).

In an attempt to mitigate the threat of overexploitation of marine resources, environmental decision makers have focused on mechanisms to protect marine ecosystems while simultaneously supporting sustainable fisheries. The use of marine protected areas (MPAs) as management tools to protect marine ecosystems has become one of the most widely applied methods of marine management (Barr et al. 2011, McClanahan et al. 2012, Jones 2014). An MPA is an area within the ocean in which human activities are managed and regulated in order to achieve the long-term conservation of biodiversity. The IUCN defines the objective of an MPA as "to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (p. 12 Day 2012). This highlights the point that the objective of MPAs is not only to conserve biodiversity but also to protect associated livelihoods and cultural values. Thus, as well as enhancing biodiversity, MPAs can complement fisheries management and support alternative livelihoods such as tourism (Roberts et al. 2001, McClanahan et al. 2009, Garcia et al. 2014, Jones 2014).

Whilst the number and extent of MPAs has increased globally over the past decade, their impacts on marine ecosystems and associated livelihoods remain uncertain (Alison 1998, Green et al. 2011, Rife et al. 2013). Current MPA knowledge has made limited progress in incorporating the examination of the socioeconomic factors into MPA planning, in particular the influence that governance and other socio-political drivers have on MPA placement choice. Several gap analyses of protected areas suggest that their placement is generally skewed towards particular areas that are less economically valuable for commercial use, which is indicative of residual placement (Pressey 1994, Rodrigues 2004). As networks of MPAs expand globally, there is a risk that new MPAs will be biased toward places that are remote, or unsuitable for extractive purposes, with less consideration of the biodiversity and livelihood values of those areas. Such locations typically provide little protection to the ecosystems and people who are most at risk from threats to marine environments (Devillers et al. 2015).

Inadequate understanding and incorporation of socioeconomic factors into MPA planning and management processes has impeded the potential for MPAs to meet conservation objectives (Christie 2004, Polasky 2008). Given that in most cases human activities provide the greatest direct threat to ecosystems and biodiversity (U.N.E.P 2007), and that the management of these threats through MPAs depends on the management of people; MPA success is contingent on socioeconomic considerations. Despite this, existing MPA planning frameworks used to guide placement are generally based largely on biophysical measures (Westera 2001, Day J. 2012, Kelleher 2012, Spalding 2013, Edgar et al. 2014), and political pragmatism (Devillers et al. 2015), with less consideration on interrelated socioeconomic factors. A contributing reason for this is the absence of an established, replicable and broadly applicable set of socioeconomic factors to support decisions concerning conservation planning and MPA placement at a variety of spatial scales (e.g. national and local).

This thesis examines relevant socioeconomic factors, and develops associated methods that can support decision-makers to designate (or place) MPAs where they are most likely to maximise positive impacts on ecosystems and livelihoods, from a national to local scale. The overall aim of this study is to identify the socioeconomic factors that influence effective placement of MPAs so that they are most likely to result in positive impacts on people and ecosystems. In addition, it aims to investigate the implications of these factors at national and local scales with respect to determining the appropriateness of MPAs as an approach to supporting marine ecosystems and associated livelihoods. In this chapter, I provide justification for this research by demonstrating that MPA placement is often driven by means other than the conservation of biodiversity. I then describe the gap in the MPA literature that exists around the incorporation of socioeconomic factors into MPA planning, and explain how this can lead to MPAs that fail to meet their conservation objectives. Finally, I present the argument that socioeconomic considerations will vary depending on the scale at which the MPA is to be implemented, and why it is important to consider national and local scale MPA implementation differently.

Justification for the research

MPA placement is often driven by incentives for countries to protect areas based on area quantity, not conservation quality. The 2002 World Summit on Sustainable Development set the first target for the establishment of a global system of MPAs. In 2010, the parties to the Convention on Biological Diversity (CBD) espoused Aichi Biodiversity Target 11, that: at least "10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes" (C.B.D. 2011).

The result has been more than 14 million km^2 of new MPAs since 2010 (UNEP-WCMC and IUCN 2019). The inclusion of “other effective area-based conservation measures” in Aichi Target 11 recognises the conservation value of areas that do not meet the formal definition of a protected area, but whose presence contribute to the conservation of biodiversity (IUCN-WCPA 2019), such as some networks of community driven management areas and temporary or permanent closures of fisheries (Watson et al. 2016).

Percentage of protection has since become the most commonly used measure to report on protected areas, providing an incentive for countries to protect areas based on size of the area (i.e. quantity), not conservation quality, thus obscuring a failure to meet biodiversity conservation objectives (Barr and Possingham 2013, Devillers et al. 2015). High level, area-based commitments continue to be made at global forums such as Our Oceans Conference, and conservation donors will often direct funding towards projects that promise to meet area-based targets for protection (OOC 2017, OOC 2019). As a result, while total MPA coverage has increased within the last decade, their conservation value remains uncertain (Rife et al. 2013). Species extinction continues to increase (Barr et al. 2011), fisheries are depleting (Worm and Myers 2003), and avoided loss or promoted recovery of ecosystems due to protection remains low (Devillers et al. 2015). One reason for this relates to the fact that not all MPAs are placed in areas where they can most positively impact both conservation or livelihood objectives (Devillers et al. 2015).

In this thesis, I consider effective MPA placement from a potential for impact perspective. Impact can be defined as the difference made by an MPA; the outcome that arises from protection compared to the counterfactual scenario of no protection (Pressey et al. 2015). Therefore, to understand if an MPA positively impacts biodiversity conservation, one should consider more than just its geographic extent, or the change in biodiversity over time. This is because, without considering other factors such as management and threats, size does not necessarily correlate with better outcomes. Also, in the absence of understanding the counterfactual scenario, it is not possible to ascertain if the difference in biodiversity is due to the MPA or other factors. When increased coverage is a central motivation, MPAs can be residual and established in areas where they least interfere with extractive activities. In fact, these MPAs may provide the least advantage to conservation if they prohibit the establishment of further MPAs in areas where threats can be mitigated, particularly if MPA coverage goals have already been reached (Devillers et al. 2015). Therefore, although there is geographic progress towards increased coverage of protected areas, little is known concerning conservation impact in relation to MPA placement (Alison 1998, Holland 2000, Green et al. 2011).

From a socio-political perspective, MPA placement has been heavily influenced by the need to minimise opportunity costs and reduce conflict with high-level stakeholders (Rodrigues 2004, Ban and Klein 2009, Barr and Possingham 2013, Jones 2014, Devillers et al. 2015). Generally, the most dominant costs in MPA planning are borne by those whose extractive uses of natural resources (e.g.

fisheries, oil and gas) are curtailed by the establishment of MPAs (Ban and Klein 2009), and management costs such as enforcement and upkeep (Arias et al. 2015, Bergseth et al. 2015, Devillers et al. 2015). In addition, costs are often borne by local, financially poor, people who utilise the natural wealth of the sea for sustaining their own livelihoods (Ferraro 2001, Sayer and Campbell 2004). While minimising costs eases compliance, enforcement, political expediency and immediate impacts on local livelihoods (Sayer and Campbell 2004, Ban and Klein 2009, Barr and Possingham 2013, Arias et al. 2015), it can also reduce overall long-term MPA impacts on biodiversity (Devillers et al. 2015).

For example, in 1998, the Australian Government established a collaborative programme with its states and territory to create a National Representative System of MPAs (NRSMPA) (A.N.Z.E.C.C. 1998, Macintosh et al. 2010). The primary goal of the NRSMPA was to 'to establish and manage a comprehensive, adequate and representative system of marine protected areas' (A.N.Z.E.C.C. 1998). Since then, Australia's MPA system has extended to cover approximately 2.3 million km^2 yet many of these areas of protection are highly remote, placed in areas of little commercial value and thus may be considered residual (Kearney et al. 2012, Hunt 2013). In addition, protection zones in the Coral Sea Marine Reserve that prohibit long line fishing of pelagic fish have been designed to cover only the most marginal areas for this fishing method (Hunt 2013), and many no-take zones have been placed in areas of already well-managed fisheries (Kearney et al. 2012). Oil and gas reserves are deficient and concentrated in areas in which oil and gas developments are absent or permitted in protected areas that were established in 2007 and 2012 (Hunt 2013). The idea of meeting targets based on percentage of area protected facilitates this false measure of conservation. Although at a glance it looks as if Australia is making worthwhile marine management efforts, it is likely that economic drivers for continued use of commercially important fisheries, and oil and gas exploration have outweighed biodiversity values when MPA zoning decisions were made (Kearney et al. 2012, Hunt 2013).

The number of Large-Scale MPAs (LSMPAs) (i.e. those greater than 100,000 km^2 in area) has been increasing since the 2010 CBD commitments, and they now account for more than 80% of the world's MPA estate (UNEP-WCMC and IUCN 2019). This reinforces global patterns for residual MPAs that focus on increasing percentage coverage rather than considerations for biodiversity impact (De Santo 2013, Devillers et al. 2015). Most LSMPAs are in overseas territories (e.g. Chagos (United Kingdom) & New Caledonia (France)) and are remote not only from most extractive activities, but also from political centres (e.g. Coral Sea (Australia)) (Devillers et al. 2015, UNEP-WCMC and IUCN 2019). This allows the respective country to increase its contribution to protected areas, while least affecting extractive activity (De Santo 2013, Devillers et al. 2015).

In contrast to remote LSMPAs, smaller-scale MPAs that are initiated at the community level are often driven by more localised socioeconomic drivers. These types of MPAs often involve a variety of management measures such as seasonal closures and traditional use zones, and can be called a variety of names such as Locally Managed Marine Areas (LMMAs) or community-based management areas.

For example, in the Velondriake region of South West Madagascar, marine resources are the primary, if not sole, protein and income for many of the local Vezo people, as well as a means for cultural identity (Oleson 2011, Barnes et al. 2013). When fish stocks in the region experienced rapid decline (Oleson 2011), the Vezo people (supported by technical partners such as NGOs) recognised the need for a better-managed resource and formed the Velondriake Locally Managed Marine Area (LMMA) network that centered on managing key species such as the commercially significant octopus (Oleson 2011, Barnes et al. 2013). Temporary closures were introduced and dramatic results were seen in the increase in size and abundance, with landing sizes increasing 718% 30 days after a closure's reopening, relative to the 30 days before a closure (Oleson 2011). While in some cases these have provided benefits from a fisheries management perspective (Oleson 2011, Barnes et al. 2013), the broader associated biodiversity value is questionable if these closures are temporary and only for some species.

Aichi Biodiversity Target 11 asserts that protected areas should be placed in areas of most importance for biodiversity and ecosystem services (C.B.D. 2011, Juffe-Bignoli 2014). As illustrated above, socio-political drivers operating at different scales may drive MPAs away from meeting those goals – political and economic drivers often skew protection towards areas of low economic value, and fishing dependent communities are often driven by the protection of livelihoods. Decisions on what should be protected depend on multiple, sometimes-competing factors, including assessment of trade-offs and opportunity costs, and other economic, social and political considerations (Juffe-Bignoli 2014). Given this, although placing an MPA in an area of high conflict may be counterproductive, placing an MPA in an area that avoids all conflict with alternative uses is likely to reduce its conservation impact.

Literature Gap

Limited attention has been placed on understanding socioeconomic considerations for MPA placement.

Many 'best practice' guidelines for MPA design and placement exist in the conservation literature (Westera 2001, Day 2012, Kelleher 2012). Some of these guidelines focus mainly on biophysical criteria (Westera 2001, Kelleher 2012, Spalding 2013, Edgar et al. 2014), which can be compromised by political processes involved in decision making, and/or are insufficiently robust (e.g. based on percentage area targets). Guidelines that do include socioeconomic considerations, often do so from a monitoring and evaluation perspective, and less so from a MPA planning perspective (e.g. A.N.Z.E.C.C. 1998, Kelleher 2012, NOAA 2015). Further scrutiny of socioeconomic and political considerations alongside biophysical considerations at the MPA planning phase is required to better inform best practice guidelines that consider socioeconomic factors with regard to MPA placement.

Some progress has been made in conservation planning with respect to broadening social considerations beyond the measure of economic considerations (Knight et al. 2006, Cowling 2007, Ban et al. 2009, Cinner et al. 2009, Mascia et al. 2010, Ban et al. 2013, Mills et al. 2014, Weeks et al. 2014). For example, Ban et al. (2009) showed the value of integrating both community-based and science-based approaches in conservation planning to achieve community compliance and conservation outcomes. Mills et al. (2014) looked into the social dimensions of systematic conservation planning, and suggested that social network analysis has the potential to be a valuable tool to support decision-making in conservation planning. Ban et al. (2013) advocated that complementing social considerations with an integrated understanding of the ecology of a region elicits a more complete approach to conservation. In addition, Cinner et al. (2009) indicated that taking into account social factors as well as ecological factors can mutually improve ecological and socioeconomic outcomes.

Given the aforementioned literature, it is apparent that interdisciplinary factors are needed to define best practice for MPA placement that emphasise the need to maximise impact for both conservation of biodiversity and for livelihoods. While MPAs have the theoretical potential to benefit resource dependent communities (e.g. by increasing fish biomass (NRC 2001, Topor et al. 2019) or reducing local competition for fishing resources (Christie et al. 1994, Himes 2003, Mascia et al. 2010)), considerations concerning how MPA-related restrictions will impact vulnerable, fisheries dependent people are often neglected.

Implications

Varying socioeconomic contexts will produce unique opportunities and challenges for MPAs.

At national levels, MPAs are often driven by broad political and economic drivers that sometimes overshadow the factors that would best support conservation impact (Rodrigues 2004, Pressey 2009, Devillers et al. 2015). These drivers can include reaching protected area targets (e.g. Aichi Target 11), or expanding political reach into overseas territories (e.g. Jeffery 2011, Dunne et al. 2014, Gifford and Dunne 2014). Local-level and community based MPAs are more likely to follow traditional tenure and management practices of the region, taking into account local values and allowing resources to recover from fishing pressures (The LMMA Network 2016). These communities however may not have the broad spatial jurisdiction and capacity required to identify sites of regional importance. Therefore, depending on the scale at which MPAs are to be implemented, different opportunities and challenges will exist for MPAs to be placed such that they provide meaningful conservation and/or livelihood benefits.

At a national-scale, some nations might be well positioned socially, politically and economically to adapt to MPA related restrictions if they have a stable and diverse economy (i.e. are not exclusively dependent on marine resource extraction), and possess a strong and ethical government that can support those individuals and industries that will be required to diversify out of fisheries as a result of protection (Guillaumont 2011). However, others nations may not be well equipped to adapt to MPA-related restrictions due to socioeconomic limitations such as systemic governmental corruption, an economy that is largely dependent on marine resources, and high levels of economic vulnerability (Crawford et al. 2006, Cinner et al. 2007, Broad and Sanchirico 2008, Guillaumont 2011, Gutierrez et al. 2011). This can be particularly challenging in developing and low-income tropical countries in which LSMPAs are more likely to be located (U.N. 2014, MCI 2019), and in which the majority of the world's wildlife populations have declined (WWF 2010). In these contexts, costs are generally experienced by local, resource-dependent fishers or communities who are more likely to have limited capacity to adapt to livelihood restrictions. A dearth of resources, institutions, and operational governance structures are likely to leave local people ill-equipped to comply with LSMPA legislation that could otherwise potentially support long-term biodiversity conservation (Barrett et al. 2011). If costs to livelihoods associated with LSMPAs are too high, resource users are likely to reduce support for LSMPAs and non-compliance to LSMPA legislation may result (Ostrom, 2007; Davies et al., 2018). If LSMPA decision makers fail to consider the socioeconomic context in which they operate, then these MPAs are unlikely to meet their conservation objectives.

The same disparity exists at a local scale, where individuals within a community will likely vary in their ability to adapt to MPA related restrictions (Crawford et al. 2006). This ability to adapt to restrictions imposed by MPAs will affect small-scale fishers' vulnerability to experiencing adverse outcomes to MPA restrictions (Adger 2006, Marshall 2010, Chen and Lopez-Carr 2015). Small-scale fishing communities are generally socially and economically heterogeneous, encompassing a variety of ethnicities, wealth, education levels, age, occupations, and social status (FAO 2015, Gurney et al. 2015). Furthermore, individuals will draw varying levels of well-being from fishing and marine environments, largely dependent on bequest and other non-use values associated with their relative environment (Beaumont et al. 2007, O'Garra 2009, Foale and Dyer 2016). Some individuals will be well-placed to adapt to MPA-related restrictions if they have the opportunity to source their income and/or sense of wellbeing from other means (e.g. farming, tourism, retail etc.). Others, may be more vulnerable if they do not have the social or economic safeguarding to support an attempt at a new livelihood strategy (MacNeil and Cinner 2013). This vulnerability to adverse outcomes of MPAs may be heightened for indigenous fishers living on ancestral land, in which bequest values are considered of particular importance (Casey et al. 2008, O'Garra 2009). These fishers are typically bound by kinship ties, and land or fishing grounds are often considered to be handed down generationally by their ancestors. Moreover, current generations can be expected to pass land onto future generations to keep the culture alive (Abramson 2000, O'Garra 2009). Ancestral land and fishing grounds have no substitutes, making them unique to the families and fishers residing in those areas. Therefore, those fishers with strong cultural ties to their environments or fishing grounds will likely find it particularly difficult to adapt to a circumstance in which accessing those land/grounds are restricted.

Applying resource restrictions to the most vulnerable community members (i.e. those with low adaptive capacity and strong cultural values) can manifest in poverty traps, a reinforcing mechanism whereby the poor remain mired in poverty unless a substantial amount of economic capital is made available (Azariadis and Stach 2005). Furthermore, when MPAs are introduced to small-scale fishing communities without considering the varying adaptive capacities of individuals and stakeholder groups, this can result in MPAs that have inequitable impacts on fishers, and where elites use their positions of status and power to promote their own interests at the expense of others (Béné et al. 2009). There is therefore a need to identify what the socioeconomic factors influence how vulnerable individuals are to experience adverse outcomes of MPA restrictions, and subsequently how to meaningfully consider the varying needs of those more vulnerable individuals within the MPA planning process.

Aims

This body of research fills a gap in the MPA literature in order to support of greater consideration of the socioeconomic dimensions of MPA planning, and increase the potential for both livelihood and conservation MPA benefits at multiple scales (national and local). This thesis aims to address the following objectives in the corresponding thesis chapters:

Chapter Two) Identify the spatially explicit socioeconomic factors for effective placement of MPAs from an impact perspective;

Chapter Three) Highlight least developed and low-income countries where large-scale MPAs are more likely to be successful in providing conservation benefits;

Chapter Four) Explore how ethnic heterogeneity influences fishers' vulnerability to experiencing negative outcomes from restrictions imposed by MPAs in small-scale fishing communities;

Chapter Five) Develop a systematic method to identify the optimal location for no-take MPAs so that they limit negative impacts on small-scale fishers with the highest levels of vulnerability to experiencing negative consequences from MPAs within a community.

Thesis Structure

I respond to the four objectives of my thesis through four data-based research chapters (Chapters Two - Five). These chapters are presented as adaptations of a series of scientific papers, formatted for publication in peer-reviewed journals, each addressing one of the previous objectives. The thesis concludes with a discussion chapter (Chapter Six) that provides a brief summary of my main findings and their interpretation, and a discussion of the implications of these findings for the advancement of theory and practice in MPA literature globally (Figure 1).

To provide a robust and broad overview of the social dimensions that influence MPA impact, I conducted a systematic review of ten years of scientific literature on the socioeconomic factors that can influence how MPAs impact on ecosystems and livelihoods (Chapter Two). The result was a list of 32 socioeconomic factors (or variables) that influence the effective placement of MPAs in terms of maximizing impact. These factors were scored according to the robustness of the methods used to evaluate impact. Chapter Three focused on understanding how a selection of the identified socioeconomic factors can support policy makers when designating national level MPAs to have positive biodiversity impacts. I focused on designated EEZ-wide restrictions on shark fishing (termed here as 'shark large MPAs') due to their increasing prevalence as national level legislation. Having assessed how national level socioeconomic factors can influence MPA impact, I scaled the research scope down to local level MPA planning for Chapters Four and Five. In Chapter Four, I investigated vulnerability in small-scale and artisanal fishers in the Myeik Archipelago, Myanmar, where fishers are operating in a context of national level economic and environmental reform. Finally, in Chapter Five I developed a systematic and spatially explicit method to identify those individuals most vulnerable to being negatively impacted by no-take MPAs through an index that represents individual-level vulnerability to experiencing negative outcomes from restrictions imposed by MPAs, and applied this method in two socially and economically diverse communities in Myanmar's Myeik Archipelago. In Chapter Six I discuss the implications and significance of this body of work within the context of relevant global literature. Findings from this research help to fill the gap in MPA literature regarding how socioeconomic dimensions of MPA planning, and can support MPA practitioners develop MPAs that maximise ecosystem and livelihood benefits from a national to local level.

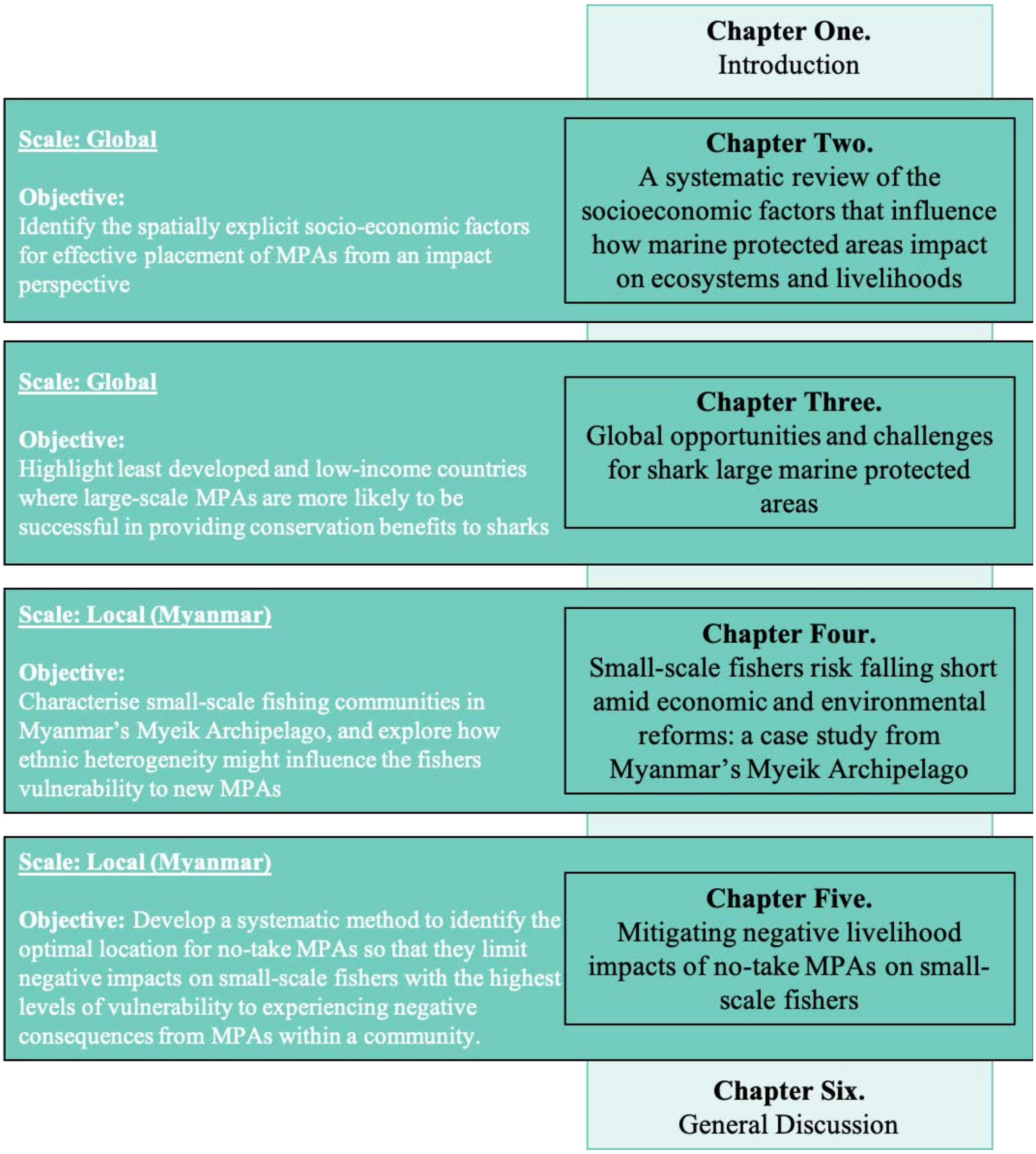


Figure 1. Schematic diagram of thesis structure

Chapter Two. A systematic review of the socioeconomic factors that influence how marine protected areas impact on ecosystems and livelihoods

Chapter Two. A systematic review of the socioeconomic factors that influence how marine protected areas impact on ecosystems and livelihoods

Forward

This chapter addresses the gap in MPA guidelines of the socioeconomic factors that promote maximum impacts of MPAs. This chapter laid the foundations for the rest of my thesis by highlighting the importance of context specific considerations to be made when incorporating socioeconomic dimensions into MPA planning. When I wrote this chapter, I was enrolled in a Masters of Philosophy, and I subsequently upgraded to a PhD upon publication of this work. This chapter was published in *Society and Natural Resources*[1].

Introduction

Marine protected areas are one of the most widely utilized marine management tools globally, designed for numerous objectives, from the recovery of biodiversity, to fisheries management, to the enhancement of tourism (McClanahan et al. 2009, Barr et al. 2011, Jones 2014, Jupiter et al. 2014, Jupiter et al. 2017). Whilst global MPA coverage is increasing, their environmental and socioeconomic impacts remain uncertain (Alison 1998, Agardy et al. 2011, Green et al. 2011, Rife et al. 2013, Bennett and Dearden 2014, Kamat 2014, Gruby et al. 2017), and avoided loss or promoted recovery of ecosystems due to protection remains low (Devillers et al. 2015). One potential reason for this is that MPAs are not all placed in areas in which they can maximize impacts on marine ecosystems and associated livelihoods (Devillers et al. 2015). Current MPA guidelines lack an interdisciplinary perspective that examines the spatially explicit factors that promote maximum impacts of MPAs. Whilst much work has focused on the biophysical criteria that define optimal placement of MPAs (Westera 2001, Day J. 2012, Kelleher 2012, Spalding 2013, Edgar et al. 2014), less consideration has been placed on interrelated socioeconomic factors such as population density and poverty (Jones et al. 2017). This study aims to (1) identify socioeconomic factors that influence the potential for MPAs to have a positive or negative impact on both ecosystems and local livelihoods through a review of scientific literature; and (2) to evaluate and discuss the level of evidence offered to substantiate these claims.

The difference made by an MPA can be described as its impact; the outcome that arises from protection compared to the counterfactual scenario of no protection (Pressey et al. 2015). Often, protected areas are residual, placed in areas where they least interfere with extractive activities, which, in effect,

[1] Mizrahi, M., A. Diedrich, R. Weeks and R. L. Pressey (2018). "A Systematic Review of the Socioeconomic Factors that Influence How Marine Protected Areas Impact on Ecosystems and Livelihoods." Society & Natural Resources: 1-17.

provides the least advantage to conservation (Devillers et al. 2015). Poorly placed MPAs may also prohibit the establishment of additional MPAs in areas where threats can be abated, if an acceptable limit of protected area extent has been reached.

Numerous gap analyses of protected areas (marine and terrestrial) suggest that protected areas are generally skewed toward particular ecosystems that are less economic- ally valuable for commercial use (Rodrigues 2004, Joppa and Pfaff 2009), indicative of residual placement. Human activities are often the greatest direct threat to natural ecosystems (U.N.E.P 2007), which means that placing an MPA in an area where there is no threat to ecosystems will have little to no conservation impact. For example, the Chagos Archipelago large-scale MPA (LSMPA) was one of the world's largest MPAs when it was established in 2010 (Dunne et al. 2014). Given its sheer size and the acclamation this MPA initially received, for example by the Pew Environment Group and Greenpeace UK (Harris 2015), it is of interest to evaluate its performance from an impact on ecosystems and livelihood perspective. From an ecosystems perspective, the Chagos Archipelago was already highly regulated and subject to a well-managed fisheries licensing system prior to the MPA's promulgation (Dunne et al. 2014), and coral reef health was in exceptionally good condition compared to other reef systems in the Indian Ocean (Sheppard 2013). In addition, 470km^2 around Diego Garcia, the only area in which evidence of overfishing exists, was excluded from the MPA, allowing for dredging and infrastructure development by US naval personnel residing there (Jeffery 2011, Dunne et al. 2014). From a livelihoods perspective, management decisions involved little to no consultation with the Chagossian indigenous population, all of whom were exiled from the Chagos islands during the 1960s and 1970s (Jeffery 2011, Gifford and Dunne 2014). There is subsequently speculation that the MPA is being used to prevent the Chagossian people from returning to the islands (Jeffery 2011, Dunne et al. 2014, Gifford and Dunne 2014), suggesting political motivations for MPA placement as opposed to livelihood or ecosystem-based considerations.

The current increase in LSMPAs (MPAs >100,000km^2) reinforces global patterns for residual MPAs, focusing on increasing percentage coverage rather than maximizing impact (De Santo 2013, Devillers et al. 2015). In contrast, small-scale marine fisheries management areas are often driven by more localized socioeconomic drivers. For example, the Velondriake locally managed marine area network in Southwest Madagascar centers on managing key species such as the commercially significant octopus (Oleson 2011, Barnes et al. 2013). When initial temporary closures were introduced, results showed a dramatic increase in octopus landings (size and abundance) (Oleson 2011). Although this can be considered a breakthrough result from a fisheries management perspective, the broader associated ecosystem bene- fits are questionable if these closures are temporary and only for some species.

Conservation of nature often involves trade-offs between biophysical and socioeconomic impacts (Stewart and Possingham 2005, Halpern et al. 2013, Plagányi et al. 2013, Waldie et al. 2016). Focusing on potential for conservation impacts from a purely ecosystem-based perspective could neglect the needs of coastal communities who rely on the natural wealth of the sea for their livelihoods and food security (Kamat 2014, Waldie et al. 2016, Christie et al. 2017), whilst solely focusing on livelihood impacts could neglect to place an MPA in an area that will have a positive impact on ecosystems (Waldie et al. 2016). Approaches to conservation that seek to avoid all impacts on people are likely to fail to avoid negative outcomes for ecosystems (Devillers et al. 2015). This can subsequently have a negative impact on resource-dependent livelihoods, potentially resulting in a destructive negative feedback loop through the establishment of illegal or destructive fishing practices. Moreover, approaches that ignore negative impacts to people may fail to achieve compliance, and thus fail to impact ecosystems positively. Finally, restricting anthropogenic pressure within a protected area can displace extractive activities into outlying zones (Agardy et al. 2011, Bode et al. 2015). Trade-offs between biophysical and socioeconomic impacts, therefore, need to be addressed in order to sup- port conservation of ecosystems and livelihoods that depend on marine resources.

I conducted a systematic review of the socioeconomic factors that influence whether MPAs have an impact on ecosystems and/or livelihoods, and evaluated the level of evidence used to evaluate impacts in each study. My objectives were to: (1) identify what socioeconomic factors have been most frequently associated with positive and/or negative impacts on ecosystems or livelihoods through a review of academic literature; (2) evaluate these factors with respect to the level of evidence provided to support their proposed relationship with impact; and (3) discuss the implications of my results for future incorporation of social considerations into MPA placement decisions. I developed a scoring system for evaluating "evidence of impact" based on the methodology used to support conclusions around the factors' influence on the impact of MPAs. Most socioeconomic studies assert that it is important to understand the particular context within which management is to be implemented. With this background, my review provides insights as to which socioeconomic factors may be more or less important in determining MPA impact in different contexts.

Methodology

Systematic Review

A systematic review is a scientifically rigorous, qualitative approach to reviewing literature, that collects and critically analyses multiple studies to answer a particular research question or topic (Uman 2011). The procedure for this review, described in the following subsections, has been adapted from Pullin & Stewart's Guidelines for Systematic Reviews (2006).

Definition of Research Question and Terms

The first step involved formulating a research question that encompassed a subject (e.g., MPAs), and an outcome (e.g., impact on ecosystems or livelihoods) to inform the definition of search terms for the review. In my case, this resulted in the question: what are the spatially explicit socioeconomic factors that influence whether MPAs are located in areas that have highest potential for impact on ecosystems and/or livelihoods?

The second step involved the definition of key terms. I broadly defined a marine protected area to be any marine area that is spatially managed to regulate human activity in order to achieve long-term conservation and livelihood outcomes. Although the importance of addressing social and ecological objectives in MPAs has been accepted globally (e.g. Day 2012), my study considered areas that may not meet the classical definition of an MPA, and focused also on additional areas intended to provide livelihood outcomes, such as some networks of community-based management areas and temporary closures of fisheries (Watson et al. 2016). For the purpose of this study, large areas (regions, provinces or EEZs) where certain species are protected by law across the entire region (e.g., nationwide shark bans) were considered as broader, con- textual legislation and were omitted from the MPA definition.

I used the term "ecosystem impact" in the broadest sense to encompass aggregated variables describing ecosystem health (e.g., reef health as a sum of fish biomass and hard coral coverage) and those encompassing one biological unit within an ecosystem (e.g., parrot fish biomass as an indicator of reef health). I used the term 'livelihoods impacts' to differentiate purely biological factors (e.g., "ecosystems") from human factors. Livelihoods have been broadly defined as comprising "the capabilities, assets (including both material and social resources) and activities required for a means of living" (page 6 Chambers and Conway 1992).

Impact, as applied in my evaluation of "evidence of impact" was defined as the difference made by the presence of a protected area: the outcomes resulting from protection relative to the counterfactual outcomes of having no protection (Pressey et al. 2015). In this context, positive impact on ecosystems occurs when MPAs are placed in areas that, had they not been there, ecosystem health would decline. Positive impact on livelihoods occurs when fisheries and livelihoods that marine resources support to improve as a result of the MPA. Positive impact also occurs with the restoration of damaged areas or the enhancement of livelihoods as a result of protection (Pressey et al. 2015). However, for reasons outlined below, I used a broader set of terms to describe impact when searching for articles to include in the review.

Literature Search

A search was conducted on the Web of Science Core Collection database for peer- reviewed journal articles in English published between 1 January 2006 and 31 December 2016. Search words included subject terms in every possible pairing of the subject–out- come related keywords (e.g., marine protected areas and impact). Subject search terms were: Marine Protected Area (MPA); Marine Reserve; Locally Managed Marine Area; Community Fisheries Management Area; Marine Fisheries Management Area; No-take Zone; Marine National Monument; Marine Park; Fisheries; and Traditional Management. Given the recent emergence of a focus on "impact" in the literature, I used additional terms to capture the notion of MPA success. Thus, my outcome search terms were: Impact; Success; Effectiveness; Social Impact Evaluation; and Socioeconomic Impact. However, I will refer to these terms collectively as "impact" throughout this review.

Pullin & Stewart (2006) suggest including an intervention in the search terms. However, the aim of my review was not to identify a specific "intervention," and was rather to identify contextual "socioeconomic factors" that influence the impact of MPAs on ecosystems and livelihoods. Simply using the term "socioeconomic factor" is too broad to capture a multitude of factors, hence, a third search term was not included. However, only articles that had a socioeconomic element to their research were included.

Table 1. Inclusion and exclusion criteria for systematic review.

Inclusion	Exclusion
Related to any form of marine or marine fisheries management system	Related to terrestrial or freshwater fisheries environmental management system
Systematic reviews	Literature reviews (non-systematic)
Socioeconomic factors directly related to people and their interactions with marine resources (e.g., stakeholder engagement, fishing pressure, market access)	Top down management measures imposed on people to alter their interactions with marine resources (e.g., fishing gear restrictions & enforcement)
Primary data to support conclusions about impact	Secondary sources to support claim of impact such as cited literature, except for in the case of a systematic review

Article Selection and Data Extraction

The first round of my data selection involved excluding articles without a socioeconomic dimension. Next, the titles and abstracts of journal articles meeting the search requirement were read and filtered based on inclusion and exclusion criteria outlined in Table 1. The remaining articles were examined and only those that paired at least one "subject" and one "output" term was included in the next stage of review. Information on the socioeconomic factor(s) influencing MPA placement, the reported relationship to the potential impact on ecosystems and/or livelihoods, the direction of impact(s), and the evidence for impact were extracted from each article meeting the selection criteria (Table 2).

Determination of Direction of Impact

I recorded the direction of impact for each factor as positive, negative, both, or nil. If a study recorded that MPAs placed in areas where “x”-factor is high led to positive impacts on ecosystems (e.g., increased biodiversity), it would be given a positive score for ecosystems impact. If a study showed that MPAs placed in areas where “x”-factor is high led to negative impacts on ecosystems (e.g., decreased biodiversity), it would be given a negative impact score. Studies could receive both a positive and negative score if results showed that “x-factor” had both positive and negative impacts on ecosystems and/or livelihoods. Thus, it is important to note that the terms “positive” and “negative” do not necessarily describe linear relationships between variables, they are a reflection of whether impacts are beneficial or detrimental to people and/or ecosystems. Studies that concluded there was no impact were not attributed an impact direction (i.e., nil impact).

Table 2. Glossary of predefined information extracted from each journal article

#	Data	Definition	Example
1	Source	Journal article reference	(Feary et al. 2011)
2	Socioeconomic Factor	The socioeconomic factor(s) described in the article as potentially influencing an MPA's potential impact on ecosystems and/or livelihoods	Taboo's & Land/Sea Tenure
3	General description of impact	What is this journal article saying in general about the impact of the socioeconomic factor(s) on ecosystems and/or livelihoods?	Periodic openings of customary closures may allow the health of the fish community to be maintained, and local fishers to effectively harvest fishes.
4	Description of livelihood impact	Do the results describe specific impact(s) on livelihoods?	Yes, Short, periodic openings of customary closures may allow local fishers to effectively harvest fishes, therefore MPAs have potential for livelihood impact
4.1	Determined at what metric	To what metric was impact on livelihoods measured? E.g. poverty alleviation, economy, local pride	Fisheries
4.2	Impact direction	When this factor is considered in placement of an MPA, will this allow for positive, negative, nil, variable impact?	Positive
4.3	Evidence for Impact Score (EIS) on Livelihoods	What was the strength of evidence provided for placing MPAs to have impact? Score based on the categories defined in Table 2	Score of '2'
5	Description of ecosystem impact	Do the results describe specific impact(s) on ecosystems?	Yes. Short, periodic openings of customary closures may allow the health of the fish community to be maintained, therefore MPAs have potential for impact fish community health
6.1	Determined at what metric	To what metric was impact on ecosystems measured? For example, fish biomass, reef health	Fish community health
6.2	Impact direction	When this factor is considered in placement of an MPA, will this allow for positive, negative, nil, variable impact?	Positive
6.3	Evidence for Impact Score (EIS) on ecosystems	What was the strength of evidence provided for placing MPAs to have impact? Provide a ranking based on the scores defined in Table 2	Score of '2'

Evidence for Impact Score (EIS)

I assessed the level of evidence provided for ecosystem/livelihood impacts on a three-point scale (Table 3) using the definition of impact described previously: the outcomes resulting from protection relative to the counterfactual outcomes of having no protection (Pressey et al. 2015). In this context, the highest scores were given to studies employing methods that evaluated impact compared to a matched counterfactual scenario (e.g., the same scenario in the absence of the MPA). Articles that did not test for impact against a matched counterfactual scenario were given a lower score. For example, if a study showed that high population density restricts reef fish biomass, and the supporting methodology compared reef biomass in areas of high and low human population without controlling for other confounding factors, then it would be allocated an EIS of "2" (e.g., evaluates impact against an unmatched counterfactual scenario). Studies that did not employ controls of any type (e.g., that measured changes over time) but used primary data to support their claim were allocated a score of 1. To ensure consistency of the scoring method, initial scoring was carried out by the primary researcher (myself) and was then checked by the three co-researchers. Finally, I produced a frequency distribution for each factor and scored them in accordance with the number of associated studies within each of the EIS categories ("overall EIS").

Table 3. Scores allocated to studies based on their evidence for impact.

Score	Evidence for Impact
3	Evaluates impact against a matched counterfactual scenario. Tests for avoided loss of ecosystems and/or livelihoods as a result of protection, or tests for avoided threats to ecosystems and/or livelihoods as a result of protection compared to a matched counterfactual scenario of no protection.
2	Evaluates impact against an unmatched counterfactual scenario. Tests for avoided loss of ecosystems and/ or livelihoods as a result of protection, or tests for avoided threats to ecosystems and/or livelihoods as a result of protection compared to an unmatched counterfactual scenario of no protection (e.g., changes inside and outside of an MPA).
1	Does not evaluate impact against a counterfactual scenario. Investigates the influence of a socioeconomic factor on an ecosystem or livelihood variable related to marine areas without control sites (e.g., changes ecosystems over time).

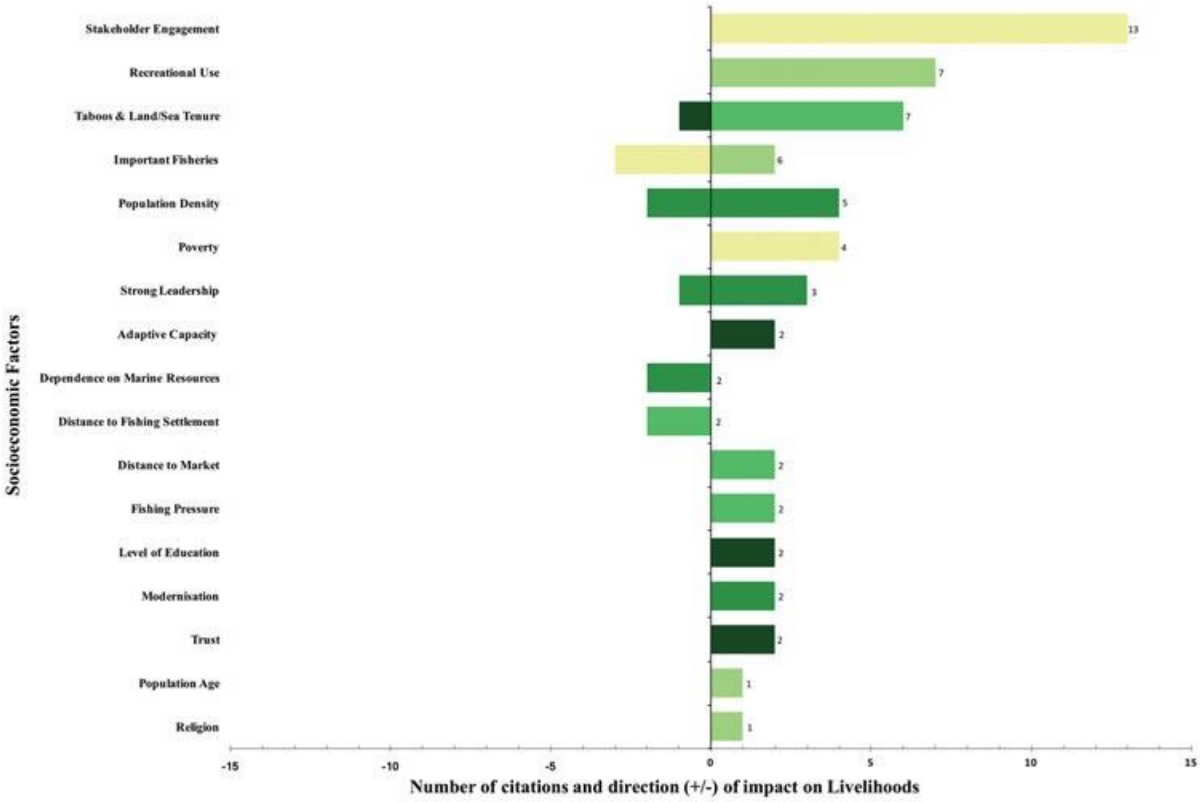
Results

An initial total of 8323 journal articles was generated as a result of the Web of Science search. After inclusion/exclusion criteria were applied (Table 1), 512 journal articles were found to contain a socioeconomic factor relevant to this review. Of these, 94 contained primary data to support conclusions about the impact (e.g., EIS=1). Within these 94 journal articles, a total of 123 associations between a specific socioeconomic factor and impact on ecosystems and/or livelihoods were recorded (e.g., some studies cited more than one factor).

Ultimately, the review identified a total of 32 unique socioeconomic factors that showed some level of evidence for impact (EIS of 1–3). Evidence supporting each factor ranged from a single journal article to a maximum of 15 journal articles. Figures 2 and 3 outlines the number of citations and overall EIS (OEIS) per socioeconomic factor, and whether they have the ability to influence whether MPA can have a positive or negative impact on livelihoods and ecosystems. Those factors that possessed both 1 journal article citations and an OEIS of 2 were omitted from Figures 2 and 3 as they were considered to have a small and/or weak evidence base for impact (see Appendix 1).

The most highly cited factors for livelihoods were stakeholder engagement (n=413), recreational use (n=47), and taboos & land/sea tenure (n=47). Those with the highest OEIS (e.g., OEIS=5) were stakeholder engagement, important fisheries (negative relationship only), and poverty. The most highly cited factors for ecosystems were population density (n=412), stakeholder engagement (n=411), and recreational use (n=49), whereas those with the highest OEIS were population density (positive relationship only), recreational use, and distance to market.

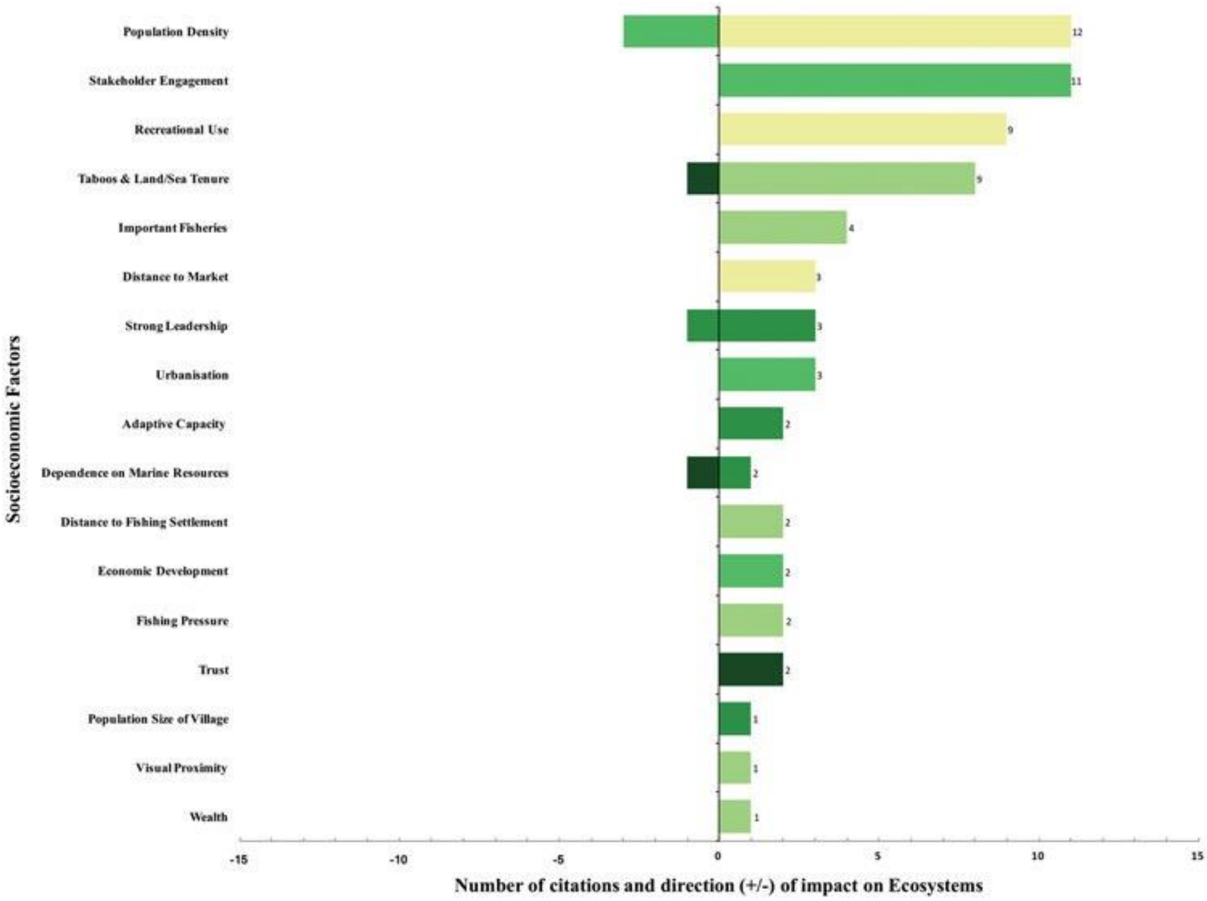
With respect to the direction of impact, six factors had both positive and negative impacts for livelihoods (Figure 2) (two were omitted from Figure 2 due to small and/or weak evidence base for impact), and four factors had both for ecosystems (Figure 3). Impacts on livelihoods were more variable (number of socioeconomic factors that had both positive and negative impacts =6) than impacts on ecosystems (n=4).



Shade	Overall Evidence for Impact Score (OEIS)	Definition
	5	If two or more studies received a maximum EIS of three
	4	If one study received a maximum EIS of three
	3	If two or more studies received a maximum EIS of two
	2	If one study received a maximum EIS of two
	1	If all studies received a maximum EIS of one

Figure 2. Number of citations and overall EIS (OEIS) per socioeconomic factor, and direction (positive or negative) of impact on livelihoods and ecosystems.

Numbers adjacent to each bar represent the total number of research articles that cite the corresponding factor. Numbers on the x axis represent the number of research articles that cite either positive or negative impact on livelihoods. Where an article reported both positive and negative impacts, this would be represented in both a positive and negative direction on the x axis. Those factors that possessed both 1 journal article citations and an OEIS of 2 were omitted as they were considered to have small and/or weak evidence base for impact.



Shade	Overall Evidence for Impact Score (OEIS)	Definition
	5	If two or more studies received a maximum EIS of three
	4	If one study received a maximum EIS of three
	3	If two or more studies received a maximum EIS of two
	2	If one study received a maximum EIS of two
	1	If all studies received a maximum EIS of one

Figure 3. Number of citations and overall EIS (OEIS) per socioeconomic factor, and direction (positive or negative) of impact on livelihoods and ecosystems.

Numbers adjacent to each bar represent the total number of research articles that cite the corresponding factor. Numbers on the x axis represent the number of research articles that cite either positive or negative impact on ecosystems. Where an article reported both positive and negative impacts, this would be represented in both a positive and negative direction on the x axis. Those factors that possessed both 1 journal article citations and an OEIS of 2 were omitted as they were considered to have small and/or weak evidence base for impact.

Discussion

This systematic review produced a list of 32 socioeconomic factors (or variables) that influenced the effective placement of MPAs in terms of maximizing impact, which I scored according to the methods used to evaluate impact (Appendix 1). Besides highlighting a diverse range of socioeconomic factors that influence MPA impacts on livelihoods and ecosystems, two important findings emerged from this review: (1) the methods for evaluating MPA outcomes are inconsistent and generally not based on counterfactual scenarios, and (2) the nature of the influence of socioeconomic factors on MPA impacts can vary in different contexts.

The articles in this review contained inconsistent, often inconclusive, methods for evaluating MPA outcomes, thus making it difficult to establish causal relationships with impact. In general, slightly more discrete factors were revealed for livelihoods than for ecosystems (28 and 22, respectively), and 17 factors pertained to both. This may simply be a reflection of the focus of this review in the social science literature (e.g., socioeconomic impacts). A number of factors differed with respect to their OEIS for livelihoods and ecosystems. For example, strong evidence existed for Poverty impacts on livelihoods (n=44; OEIS=45) (Tobey and Torell 2006; Andam et al. 2010; Ferraro and Hanauer 2014; Gurney et al. 2014), with no evidence for impacts on ecosystems. Although there is currently documentation of the strong correlation between human poverty and areas of high biodiversity (Fisher and Christopher 2007), further research into how poverty affects these marine ecosystems from an impact evaluation perspective is required.

In addition, whilst certain factors had correspondingly high citations and high OEIS (e.g., Stakeholder Engagement for livelihoods); this was not the case universally. For example, with regards to impact on livelihoods, poverty possessed an OEIS of +5, without particularly high corresponding citations (n=4); and taboos and land/sea tenure possessed a relatively lower OEIS (+=3; -=1) with higher corresponding citations (n=7). In addition, only one study researched the impact of Population Age and Religion on livelihoods (Gurney et al. 2015). However, both these factors received an OEIS of 4. Wealth and the Visual Proximity of a site also received an OEIS of 4 for ecosystems with only one citation for each factor (McClanahan et al. 2006). Where a minimal number of studies exist with strong impact evidence, this suggests the possibility that these factors have been somewhat overlooked in MPA planning, and warrants greater consideration by researchers, and by those incorporating socioeconomic considerations into MPA design. For those factors that are cited multiple times but possess low OEIS (e.g., taboos and land/sea tenure for livelihoods), further research using more impact-orientated methods could ground these factors in a stronger base of evidence.

Impact evaluation is an important and emerging field of study for protected areas (Devillers et al. 2015, Ferraro and Pressey 2015, Pressey et al. 2015, Chauvenet and Barnes 2016, Watson et al. 2016), as surprisingly little is still known regarding how much difference MPAs actually make to ecosystems and/or livelihoods. I recognize that there are limitations to the practicality of conducting impact evaluations in MPAs, particularly in small-scale community management areas in which resources may be low. However, when the impact is assessed, it can strengthen and solidify the knowledge to support creating MPAs that meet ecosystem and livelihood objectives. In scenarios where impact evaluation against a matched counterfactual scenario is unachievable, simply acknowledging the definition of impact in MPA placement and design could prove useful to ensure that MPAs are produced to have an impact, rather than reinforce patterns of residual MPAs.

Our second key result was that a number of factors displayed varied "direction of impact" (Figures 2 and 3), often within the same study, suggesting their influence varies depending on context. Several reflected these ambiguities for both ecosystems and livelihoods. Factors that were most bidirectional in nature are discussed below.

Crawford et al. (2006) and Gutierrez et al. (2011) both found that Strong Leadership led to MPAs with greater positive impacts on ecosystems and livelihoods. However, according to Sutton and Rudd (2015), strong local leadership also has the potential to be detrimental if leaders use power to capture benefits associated with marine resources, underlining that contextual differences can influence positive or negative impact. Based on this evidence, it appears that when strong leaders are apparent, policy makers should work closely with them during the development process, particularly when gaining support during the early stages of MPA planning, and be alert to the potential for elite capture. Alternatively, if strong leaders are not present, I advise that policy makers continue to work with others in non-leadership roles, as strong leadership might not be essential to achieve positive impact.

The incorporation of existing Taboos & Land/Sea Tenure into MPA planning also revealed strong, yet slightly variable, evidence for positive impact on both ecosystems and livelihoods (Cinner et al. 2006, McClanahan et al. 2006, Cinner et al. 2007, Clarke and Jupiter 2010, Weeks et al. 2010, Feary et al. 2011, Mangubhai et al. 2015, Cinner et al. 2016). From an ecosystems perspective, Cinner et al. (2006), Aswani et al. (2007) and McClanahan et al. (2006) found that MPAs in areas of self-governing customary management systems experienced improved fish size, biomass, and fish com- munity health. From a livelihoods perspective, Mangubhai et al. (2015) found that placing an MPA in an area of existing tenure could generate a greater likelihood for compliance and support for the MPA. In addition, traditional tenure systems that are used as a basis for periodic closures have been shown to increase fisheries catch (Cinner et al. 2006) avoid displacement of harvesting communities (Cinner et al. 2007), and people with strong connections with the sea can act as custodians, rather than over-harvest their reefs (Cinner et al. 2016). However, according to Foale et al. (2011), customary fishing taboos typically follow cycles that respond to social rather than ecological cues. Therefore placing MPAs in taboo areas that do not account for fishing pressure or biophysical factors related to the fished species may fail to achieve a positive impact on ecosystems or livelihoods, or may displace fishing efforts outside of taboo areas (Foale et al. 2011). Based on the aforementioned, although MPAs that follow traditional tenure systems have potential to have positive impacts on biodiversity and livelihoods, these types of MPAs will generally form from the objective of fisheries management, and should, therefore, be incorporated into broader conservation initiatives in order to produce positive ecosystem impacts.

Important Fisheries (e.g., areas where fisheries are a primary source of livelihoods) was also bidirectional. Placing an MPA in an area with fisheries importance has high potential to have positive impacts on ecosystems, as protection will encourage the recovery of harvested species and subsequently their broader environment (Coffman and Kim 2009, Burgess et al. 2013, Bertocci et al. 2014, Kamat 2014, Howarth et al. 2015). Some evidence also suggests that, over time, placing MPAs over important fisheries will also be beneficial to livelihoods, as there is potential to increase important fisheries abundance and the proportion of individuals of commercial size (Bertocci et al. 2014, Howarth et al. 2015). However in the short term, these MPAs may have negative impacts on people who rely on these resources as their main source of livelihoods, unless provided with an alternative, sustainable livelihoods (Kamat 2014, Santos and Brannstrom 2015). Broad and Sanchirico (2008) and Cinner et al. (2007) also found that communities most reliant on fishing for their livelihoods are less likely to support marine reserve creation. If communities do not support the MPA, there is less likely to be compliance and ecosystems may not improve as a result (Broad and Sanchirico 2008). Therefore, although MPAs in areas of high use has potential to benefit livelihoods in the long term, these findings suggest that positive impact depends on resource users being engaged in MPA planning through stakeholder consultations, and through the availability of alternative livelihood opportunities.

Although not evaluated as part of this review, it is important to note that the ability for any factor to inform planning will depend upon the spatial scale at which it is relevant, compared with the spatial scale at which planning is undertaken. For example, in a regional-scale MPA, planners might choose to engage with villages that have local tenure, strong leaders, and/or are closer to markets. At other scales, those factors might be homogenous (e.g., if resource dependence is uniformly high). Thus, the scale of the MPA is an important consideration for the incorporation of these factors within the MPA planning process. In addition, planners need to understand the socio-political context (e.g., political and economic drivers) and where the MPA will fall on the governance spectrum (managed locally, nationally or regionally). Only then should MPA practitioners consider the socioeconomic factors outlined in this review (alongside bio-physical criteria) and decide at what scale, and in what way, they should be incorporated into the spatial MPA design process.

The articles included in the review were largely focused on community-based management in non-industrialized countries, with only six examples of LSMPAs emerging (Fletcher et al. 2015, Januchowski-Hartley et al. 2015, Lamb et al. 2015, Richmond and Kotowicz 2015, Wynveen and Sutton 2015, Turner et al. 2016). This is possibly because socioeconomic factors are often considered most important where compliance must be won through local support (Waldie et al. 2016, Jupiter et al. 2017). The paucity of evidence for impact evaluation in LSMPAs highlights a research gap for understanding the impacts of large MPAs when they are distanced from extractive activities (e.g., Chagos), in overseas territories (e.g., New Caledonia, France) or far from political centers (e.g., Coral Sea, Australia).

Conclusion

Understanding the social dimensions of marine and coastal areas is a crucial component of MPA spatial planning. These dimensions are, however, often neglected or considered in a less systematic way than biophysical dimensions, likely due to the complex nature of socioeconomic factors and the lack of standardized guidelines that incorporate these factors into the MPA planning process. This systematic review has identified a set of socioeconomic factors that should be taken into consideration when planning future MPAs. It has also highlighted the importance for policymakers to consider the context- and scale-dependent bidirectional nature that social dimensions of marine areas exhibit, when planning MPAs that aim to maximize conservation impact, and minimize undesired negative effects on resource users.

Finally, this study highlights a lack of consistent, robust methods for evaluating the influence of socioeconomic factors on MPA impacts. Furthermore, the disconnect between evidence of impact scores and the frequency of citations for a number of factors suggest that some factors that receive a lot of attention need more robust evaluation, whereas other, less recognized factors warrant more consideration. Understanding which of these socioeconomic factors will lead to MPAs that have positive impacts is critical to the MPA planning process.

My results can be used as a tool to support MPA planning and to highlight gaps in impact knowledge from a social perspective. Before a final interdisciplinary set of guidelines for MPA placement can be produced, further research on socioeconomic impact evaluation needs to be attempted.

Chapter Two Summary

Chapter 2. A Systematic Review of the Socioeconomic Factors that Influence How Marine Protected Areas Impact on Ecosystems and Livelihoods

Abstract: Marine protected areas are among the most widely accepted methods of marine management. MPAs are not, however, always placed such that they can maximize impact on conservation and livelihoods. Current MPA guidelines fall short in focusing primarily on biophysical criteria, overlooking interrelated socioeconomic factors. We identified 32 socioeconomic factors that influence whether MPA placement has an impact on biodiversity and/or livelihoods and weighted the quality of evidence using a novel "Evidence for Impact" Score. Results suggest that stakeholder engagement, poverty, population density, and strong leadership have most potential to positively impact biodiversity and/or livelihoods, but the direction of impact (i.e., positive or negative) can be context-dependent. We found a generally poor evidence base for impact evaluation of socio- economic factors: though some factors were highly cited, few studies actually evaluate impact. Results indicate the need for a more inter- disciplinary approach to MPA placement and more empirical studies that assess impact.

Mizrahi, M., Diedrich, A., Weeks, R., & Pressey, R.L. (2018). "A systematic review of the socioeconomic factors that influence the impacts of marine protected areas." Society & Natural Resources **31** (1): 1-17.

Chapter Three. Global opportunities and challenges for shark large marine protected areas

Chapter Three. Global opportunities and challenges for shark large marine protected areas

Forward

Prior to writing this chapter, I was given the opportunity to be a part of the Shark & Ray MPA group (2020), led by Prof. Colin Simpfendorfer and Dr. Amy Diedrich. This group, funded by the Shark Conservation Fund (2020), was formed with the goal to develop an improved approach to the assessment and planning of MPAs for conservation and management of sharks and rays. This chapter provided a critical component of socioeconomic dimensions to designing shark MPAs, and acts as a useful example given the global increase in number of LSMPAs that are directed towards conserving sharks. Country level data from the Challenge and Opportunity Indices developed in this chapter have been incorporated into an online 'app' to support MPA practitioners, policymakers and donors, to identify where, and if shark MPAs are most likely to provide benefits to sharks, rays, and the communities that depend on them. This app is currently in its final stage of development, due to launch in late 2020. This chapter was published in *Biological Conservation*[2].

Introduction

Sharks (class Chondrichthyes) play an important functional role in the top-down control of marine ecosystem structure and function (Stevens et al. 2000, Ferretti et al. 2010, Dulvy et al. 2014). Shark fisheries also support the livelihoods of coastal communities across the globe (e.g. Barbosa-Filho et al. 2017, Jaiteh et al. 2017). However, decades of overfishing and habitat degradation, coupled with lucrative markets for shark products (Dent and Clarke 2015), have resulted in altered and declining populations of many shark species (Dulvy et al. 2014).

Different approaches have attempted to address the threats posed by fishing to shark populations (Dulvy 2017). One recent trend has been for coastal nations to implement legislation that prohibits the targeting, possession, sale and trade of sharks and shark products (al- though laws vary in detail) throughout their entire Exclusive Economic Zones (EEZ) (Ward-Paige and Worm 2017). While these types of legislation, hereafter termed Shark Large Marine Protected Areas (SLMPAs), now cover > 3% of the world's oceans (Davidson and Dulvy 2017, Ward-Paige 2017), their impact on shark biodiversity and associated livelihoods remains unclear.

Some studies that have assessed the impact of SLMPAs on shark biodiversity found that, in certain cases, they offer potential to provide significant protection to certain species (e.g. White et al. 2017) or

[2] Mizrahi, M., Duce, S., Pressey, R.L., Simpfendorfer, C.A., Weeks, R., Diedrich, A. (2019). "Global opportunities and challenges for Shark Large Marine Protected Areas." Biological Conservation **234**: 107-115.

can increase relative shark abundance compared to no protection (e.g. Ward-Paige and Worm 2017). However, SLMPAs are often residual to extractive uses (Devillers et al. 2015), or have limited political will and national capacity for enforcement and education programming to support active implementation, and legislative gaps that do not address key issues such as bycatch or transshipment (Ward-Paige 2017). Furthermore, meaningful legislation can be challenging to implement in countries characterised by expansive and remote ocean territories, small human populations or a large number of foreign fishing vessels (Ward-Paige 2017). The establishment of residual or insufficiently

enforced SLMPAs can lead to a false sense of protection (e.g. Cramp 2018), and inhibit the establishment of other conservation measures that may provide more benefits towards sharks. For example, in 2009, Myanmar's Department of Fisheries instated an Order under a CITES (the Convention on International Trade of Endangered Species and Wild Fauna and Flora) letter decreeing a nationwide ban on all targeted shark fishing (DoF et al. 2015). While a legal notification of the ban was assigned, no clearly defined goal or management plan supported the announcement, and the absence of any Fisheries patrol vessels resulted in a limited capacity to enforce the ban. Furthermore, incidental catches (or those reported as such) of sharks and the subsequent selling of these catches appears to be legal or is tolerated by authorities (Howard et al. 2015). Current records suggest that shark populations continue to decline in Myanmar, and significant sightings of sharks at landing sites throughout the country indicates a lucrative and active market for shark products exists despite the ban (Howard et al. 2015). While Myanmar's ban suggests some political intent to support shark conservation, limited capacity to enforce such restrictions has resulted in legislation that is currently operationally redundant, with little to no impact on shark biodiversity.

In contrast, SLMPAs that are firmly governed and enforced often come at a cost to local resource-dependent communities who rely on shark fisheries for their livelihoods, particularly so when SLMPAs cover a nation's entire EEZ, and therefore do not allow for fisher displacement. While the establishment of SLMPAs at times involves the broad incorporation of stakeholders into the planning process, ultimate decision-making and funding remains with government (Gaymer et al. 2014). These ‘top-down’ approaches to conservation tend to have less stakeholder engagement in planning and implementation stages, com- pared to ‘bottom-up’ initiatives, such as locally managed marine areas, that focus on local- rather than national-level objectives (Gaymer et al. 2014). Resource users often suffer from a lack of time, resources or capacity to adapt to blanket, top-down prohibitions (Dunne et al. 2014, Jaiteh et al. 2016). This is particularly true for least developed and low income countries in which SLMPAs are becoming increasingly employed (Ward-Paige 2017), and where the natural wealth of the sea provides one of the few opportunities for protein and income. If costs to resource users are too high, then SLMPAs may fail to achieve compliance, and benefits to sharks are likely to fall short as a result. For instance, in 2013 the entire territorial waters of Raja Ampat, West Papua, were designated a ‘Shark Sanctuary’. Indonesia ranks as the largest producer of shark products in the world (FishStatJ 2015, Jaiteh et al. 2017) and thus, from a biodiversity perspective, shark populations should stand to benefit considerably from such a ban. However, shark fisheries have also supported local Indonesian fishers for several decades, many of whom lost their primary livelihoods as a result of the ban (Jaiteh et al. 2016). According to recent assessments, many local fishers felt that decision makers did not take their needs into consideration when applying the ban, and a lack of stakeholder engagement meant that many fishers did not understand the goal of the Shark Sanctuary (Jaiteh et al. 2016). Giakoumi et al. (2018) recently reported that stakeholder engagement is the most significant factor influencing MPA success, and that its absence is central to influencing failure. The absence of stakeholder considerations in SLMPAs planning not only adversely impacts resource users, it will likely result in a negative feedback loop whereby biodiversity conservation goals will fail as a result of non-compliance.

The aforementioned failures are largely due to a general oversight by high level decision makers and funders to consider the socio- economic context of those nations designating SLMPAs, including whether or not they are well equipped to move these laws from written legislation into practice, and how this will impact communities de- pendent on shark catches (McClanahan 1999, Christie P 2003). While SLMPAs have the potential to positively impact shark populations, and may be relatively straightforward to legislate, such top-down EEZ-wide restrictions might not always be the most appropriate conservation intervention, and a country's political and socioeconomic characteristics will influence if and how SLMPAs can improve conservation outcomes for sharks.

Some progress has been made towards incorporating social considerations into MPA planning (Gruby et al. 2016), and shark conservation strategies (e.g. Jaiteh et al. 2016, Davidson and Dulvy 2017, Jaiteh et al. 2017). However, socioeconomic dimensions are generally considered less than their biophysical and ecological counterparts when designating SLMPAs (MacKeracher et al. 2019) . These dimensions are fundamental to planning SLMPAs, because for protected areas to have positive biodiversity and abundance impact (the outcome that arises from protection relative to the counterfactual outcomes of having no protection), trade-offs will likely exist between benefits to biodiversity and costs to livelihoods (Pressey et al. 2015, Mizrahi et al. 2018). Costs to livelihoods may be considered manageable if benefits to bio- diversity are great, and if resource users have the capacity to adapt to livelihood changes (Pradhan and Leung 2004, Naidoo and Ricketts 2006, Marshall and Marshall 2007, Cinner et al. 2009). However, most SLMPAs have been designated in developing coastal nations (U.N. 2014), possibly because largescale MPAs are financially more efficient to establish compared to smaller MPAs (Wilhelm et al. 2014). In such contexts, costs are generally born by local resource dependent com- munities who have limited capacity to adapt to livelihood restrictions. When costs to livelihoods are too high, resource users are likely to feel alienated and reduce support for conservation (Ostrom 2007, Davies et al. 2018). If policy makers fail to consider the socioeconomic context in which they operate, then SLMPAs are likely to fail to meet their conservation objectives.

In this paper, I aimed to highlight least developed and low-income countries where SLMPAs are more likely to be successful in providing conservation benefits to sharks. To do so, I identified national-level socioeconomic factors and supporting data, and conducted principal component analysis to generate two national-level indices representing anticipated challenges and opportunities for SLMPAs implementation. In the following sections, I explain the calculation and justification for my indices, and present examples to support their interpretation. I then describe how these indices may support policy makers to decide when a nation's socioeconomic context will be conducive for SLMPAs to maximise benefits to sharks, and to identify situations in which alternative strategies may be more effective.

Methods

In Chapter One, I completed a systematic review that identified spatially explicit socioeconomic factors that influence whether MPAs have impact on ecosystems and livelihoods. For Chapter Two, I adapted these factors to be relevant to SLMPAs, then identified the best available, broad-scale datasets to represent each of these factors across 87 nations. I defined a SLMPA as the legislative restriction of the targeted capture of sharks within a nation's entire EEZ. I then used principal component analysis to construct national-level socioeconomic indices reflecting the potential for SLMPAs to achieve positive impacts on shark biodiversity in least developed and low income countries.

Chapter One's systematic review identified 21 socioeconomic factors at a variety of spatial scales. Because my focus for Chapter Two was at the resolution of whole EEZs, I eliminated or adapted factors not relevant at a national scale (e.g. visual proximity of a community to a marine site), and were left with 11 national-level socioeconomic factors: Corruption; Dependence on Marine Resources; Economic Development; Economic Vulnerability; Education Levels; Fishing Pressure; Population Density; Poverty; Proportion of Youths; Tourism Potential and Urbanisation (Table 4). Next, I searched for the most recent, publicly available, national-level datasets to represent each of the remaining 11 factors to be used for principal component analysis and used the most recent data available from each source (Table 4). While I searched for full global datasets to represent each factor, many of the factors identified in the systematic review were particularly relevant to least developed and low income countries, with some indicators (e.g. Economic Vulnerability Index) only available for these nations. Thus, my final dataset represented 87 coastal least developed and low income countries.

Finally, to develop an index for anticipating opportunities for and challenges to SLMPAs based on national level socioeconomic factors, I conducted a principal component analysis of a correlation matrix of the 11 factors (Table 4) using SPSS (v.25). I used the Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity to test my assumptions for the analysis and used Kaiser's criterion for retaining factors. Factor loadings > 0.4 were retained for interpretation in accordance with Fornell and Larcker (1981). I ranked the 87 countries in my sample based on their two component scores.

Table 4. Socioeconomic factors (adapted from Chapter One) that influence whether Shark Large MPAs would be well positioned to impact shark biodiversity.

Refer to Chapter One for references to the original literature supporting each socioeconomic factor.

Socioeconomic Factor	**Relationship with Shark Biodiversity and/or Abundance Impact**	**Dataset and Source**
Economic Vulnerability	Nations with low economic vulnerability and higher adaptive capacity are more likely to comply with restrictive regulations, thereby allowing MPAs to maximise potential to make a difference. High economic vulnerability can result in bans that are not adhered to and therefore do not differ ecologically from fished areas.	United Nations database for Economic Vulnerability Index (EVI) Source: http://www.ferdi.fr/en/indicator/retrospective-economic-vulnerability-index
Dependence on Marine Resources	National level bans have potential to make a positive impact here if communities comply with MPA regulations.	Fishing as a proportion of Gross Domestic Product (GDP), Sea Around Us: Sum of Total landing value US$ (discards and recreational use removed) divided by GDP (constant US$) from World Bank. World Bank Source: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD Sea Around Us: http://www.seaaroundus.org/data/#/search
Economic Development	Marine biodiversity and biomass decreases with proximity to greater economic development.	Percentage GDP per capita growth (annual). World Bank Source: https://data.worldbank.org/indicator/NY.GDP.PCAP.KD.ZG
Fishing Pressure	Introducing Shark large MPAs in areas of high shark fishing pressure would decrease pressure on sharks.	Sea Around Us Chondrichthyan catch data (tonnes caught per EEZ) divided by EEZ size (square kl) Sea Around Us: D. Pauly and D. Zeller, editors. 2015. Catch Reconstruction Source: concepts, methods and data sources. Online Publication. Sea Around Us

Socioeconomic Factor	Relationship with Shark Biodiversity and/or Abundance Impact	Dataset and Source
		(www.seaaroundus.org). University of British Columbia EEZ file: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 10. Source available online at http://www.marineregions.org/. https://doi.org/10.14284/312
Education Levels	Formally schooled fishers and community members are more likely to be aware of, understand and support conservation efforts such as MPAs.	Human Development Index (HDI) Education Index. Calculated using Mean Years of Schooling and Expected Years of Schooling. Source: http://hdr.undp.org/en/data
Proportion of Youths	Restrictive shark fishing legislation in nations with younger populations have potential to have positive impact due to increased openness to embrace change.	Population ages 15-24/ national population = percentage of youth population. Source: https://www.prb.org/international/indicator/population-age1524-2017/table AND https://data.worldbank.org/indicator/SP.POP.TOTL
Population Density	Literature is varied: some studies suggest that people in low human population areas have not yet developed conservation ethic, therefore spatial protection has the potential to make a difference to alleviate the threat of future overuse in smaller populations. Others suggest that small-scale marine management can progress in smaller communities quickly. However, in general, national level shark fishing bans placed in nations with high population density are more likely to positively impact sharks due to higher rates of fishers that are restricted.	Population Density x (area country/area EEZ). Population Density measured at World Bank: number of people per square km. Source: https://data.worldbank.org/indicator/EN.POP.DNST
Poverty	If people perceive that benefits of MPAs are supporting them out of poverty, they are more likely to comply with restrictive regulations.	Multidimensional Poverty Index (percentage of population in multidimensional poverty). United Nations Development Project

Socioeconomic Factor	Relationship with Shark Biodiversity and/or Abundance Impact	Dataset and Source
		Source: http://hdr.undp.org/en/data
Tourism	Support for conservation from tourism reliant nations have rollover results on the environment through higher likelihood of compliance to restrictive regulations. Shark bans have potential to make a difference in areas of importance for tourism and recreational use, if tourism is managed accordingly.	Percentage of GDP arising from tourism, World Tourism Organisation, World Travel and Tourism Data Source: https://knoema.com/atlas/topics/Tourism/Travel-and-Tourism-Total-Contribution-to-GDP/Contribution-of-travel-and-tourism-to-GDP-percent-of-GDP?action=export&gadget=tranking-container&action=export&gadget=tranking-container
Corruption	National level shark fishing bans can make a difference more quickly when placed in areas with strong leadership and low levels of corruption, resulting in high compliance and positive shark biodiversity impacts. However, 'strong' local leadership can also be detrimental if 'leadership' involves using power to capture benefits therefore low corruption levels are important.	Transparency International Corruption Perceptions Index. Used as proxy for Strong Leadership and Trust. Source: https://www.transparency.org/news/feature/corruption_perceptions_index_2017
Urbanisation	Urbanised areas have greater biodiversity loss, therefore national level shark fishing bans can support resilience of shark biodiversity in areas of high urbanisation.	ESRI - World Cities Population point shapefile Created: Jul 1, 2013 Updated: Feb 8, 2017

Results

Kaiser-Meyer-Olkin's measure of sampling adequacy was 0.59, and Bartlett's test of sphericity was significant ($\chi 2 = 133.81$, $p \leq 0.01$) indicating that the data were well suited for a principal component analysis (Field 2018). I retained two un-rotated components (Table 5), accounting for 42% and 33% of the variance in the sample respectively. I interpreted these components as 'Challenge' and 'Opportunity' indices based on which socioeconomic factors contributed most to the variability across the component (Table 6). 'Challenge' nations were characterised by having relatively high dependence on marine resources, high economic vulnerability, high levels of corruption and low levels of education (Table 6). 'Opportunity' nations also had high dependence on marine resources and high economic vulnerability, however they also had high tourism and low levels of corruption (Table 6). Component scores and associated data for each nation can be found in Appendix 2. Pearson's rank correlation showed that the Challenge and Opportunity components were uncorrelated ($rs = 0.49$ $p \leq 0.01$), although the distribution of each nations component score (Fig. 4) suggests a weak negative linear relationship, with a number of outliers.

Eighty-seven coastal least developed and low income countries were each attributed 'Challenge' and 'Opportunity' scores based on each country's corresponding component 1 and 2 score (Fig. 5). Gambia ranked highest on the Challenge Index, followed by Comoros, Solomon Islands, Sierra Leone and Senegal. The Maldives ranked highest on the Opportunity Index, followed by the Seychelles, Bahamas, Cabo Verde and Dominica. Seven of the countries that I included in my analysis have current active SLMPAs throughout their entire EEZs, which exist across a range of Opportunity and Challenge scores. These include the Bahamas (Challenge rank/87 nations (C): 31; Opportunity rank/87 nations (O): 3), Israel (C: 86; O:31), Brunei (C:76; O:24), Indonesia (C:46; O:57), Honduras (C:34; O:52), Myanmar (C:15; O:68) and the Maldives (C:6; O:1) (Appendix 2). This allows me to examine contextual factors in more detail, to aid interpretation of my indices.

Table 5. Total variance explained by the factors emerging from the Principle Component Analysis.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	2.124	42.472	42.472	2.124	42.472	42.472
2	1.634	32.689	75.161	1.634	32.689	75.161
3	.585	11.698	86.860			
4	.422	8.438	95.298			
5	.235	4.702	100.000			

Table 6. Unrotated component matrix containing factor loadings for components 1 (Challenge) & 2 (Opportunity).

High loading values are highlighted in bold.

Socioeconomic Factor	Component	
	1 "Challenge"	2 "Opportunity"
Economic Vulnerability	.67	.50
Dependence on Marine Resources	.69	.53
Level of Education	-.88	.26
Tourism	-.11	.80
Corruption	.63	-.62

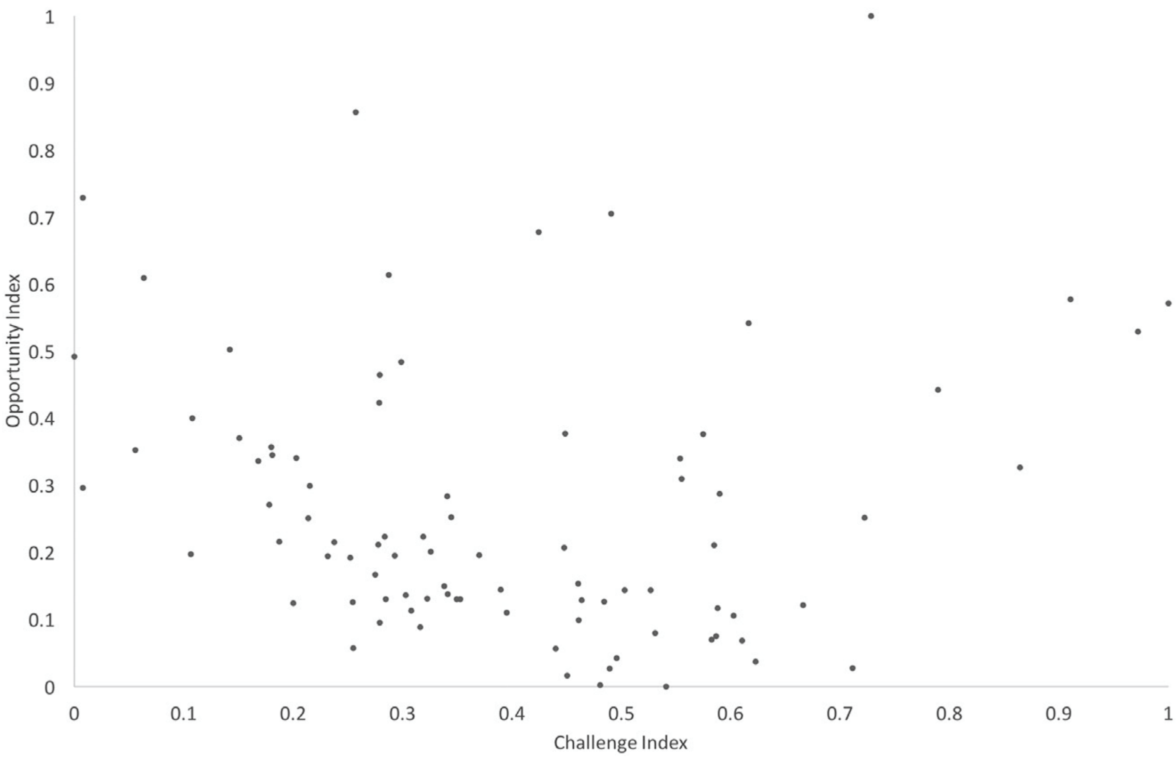


Figure 4. Standardised distribution of potential challenges compared to opportunities for low income and developing nations to effectively implement Shark & Ray MPAs.

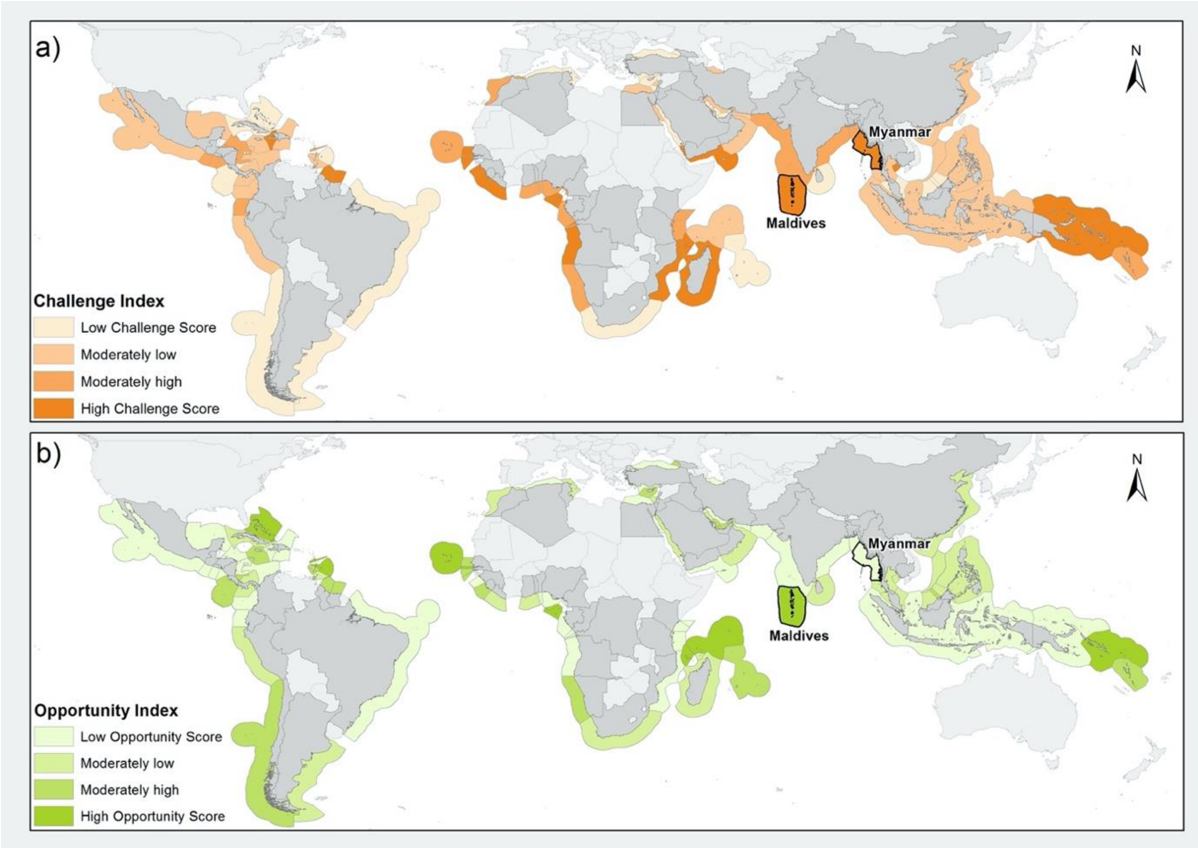


Figure 5. Level of challenge and opportunity for low income and developing nations to support the successful implementation of EEZ-wide Shark Large MPAs (SLMPAs) that achieve biodiversity benefits to sharks.

Countries shaded in dark grey are those for which the Challenge and Opportunity indices were calculated. Highlighted in black are examples of two countries with current, active SLMPAs.

Discussion

Socioeconomic factors are too often neglected by decision makers when planning shark conservation strategies (MacKeracher et al. 2019). This study has developed two national-level indices that de- scribe potential socioeconomic challenges and opportunities for SLMPAs to achieve positive biodiversity impacts in least developed and low income countries. These indices identify those nations in which socioeconomic conditions are favourable for SLMPAs to be successful in providing conservation benefits to sharks, and nations in which other shark conservation measures should be considered. In the following sub-sections, I present in more detail the challenges, opportunities and potential trade-offs reflected in my indices, including their relevance to SLMPA implementation. I describe two EEZ-wide SLMPA examples to demonstrate how the results from my study can guide shark conservation strategies at a national level.

Challenges and opportunities for SLMPAs

The Challenge and Opportunity Indices are composite scores that describe the degree to which a nation's socioeconomic context presents challenges and opportunities for SLMPAs to benefit shark biodiversity. Most nations described in this study were characterised as being somewhat dependent on marine resources, increasing potential for a SLMPA to benefit shark biodiversity, but presenting challenges to livelihoods if fishing restrictions are implemented. These nations also typically had limited adaptive capacity, characterised by having high economic vulnerability (Table 4). However, for nations that scored highly on the Challenge Index, these socioeconomic conditions were exacerbated by low education levels, which can also negatively affect adaptive capacity (Lutz 2010), and high perceived corruption levels which has the potential to negatively influence compliance and governance effectiveness (Ostrom 2007). These socioeconomic attributes describe nations that may not yet be in a position developmentally to support communities to adapt to a loss of access to resources, or to manage and enforce broad scale restrictive legislation. Furthermore, costs to resource users will likely be too great to gain support for SLMPAs in the absence of alternative livelihood opportunities. Therefore, it could be more beneficial for funders and decision makers in high ‘Challenge’ nations to direct shark conservation efforts from the bottom-up: focusing on diversifying livelihoods, and supporting education and awareness raising campaigns, in order to build socio- economic resilience prior to broader scale, top-down shark-protection regulation such as SLMPAs. Furthermore, strategies that focus on behaviour change from the bottom-up (e.g. campaigns that aim to reduce local demand for shark products), can useful in aiding shark conservation in ‘Challenge’ contexts, as they require little to no enforcement capacity. Whilst it may be unrealistic for conservation practitioners to address socioeconomic problems such as corruption and poverty (Sanderson and Redford 2003, Kiss 2004, Sanderson and Redford 2004, Terborgh 2004), my results point to the need for policy makers to reframe their approach to shark conservation in these nations by working with development aid, livelihood development, environmental awareness raising and fisheries management before top-down conservation initiatives can be effective.

Like the Challenge Index, nations that rank highly on the Opportunity Index are typically dependent on fishing and have high economic vulnerability. These are fundamental characteristics of most coastal developing nations. However, greater potential for tourism in high 'opportunity' nations indicates that opportunities are available for livelihood diversification, and lower corruption levels suggest a potentially higher likelihood of compliance if effective governance is present. Although tourism may not directly benefit the lives of fishers, ecotourism through a sustainable livelihoods approach (Scoones 1998) can provide economic benefits to locals living near those areas and subsequently build support for conservation among those populations (Scoones 1998, Nyaupane and Poudel 2011, Vianna et al. 2012). Income generated from shark related tourism has been shown to filter through the economy in countries such as Palau, where shark diving contributed to US$1.2 million in salaries to the local community, and directly generated US$1.5 million in taxes to the government (Vianna et al. 2012). Furthermore, those that perceive they are benefitting from shark related tourism may be more likely to support MPAs (Diedrich 2007) and comply with regulations that restrict extractive activities (Arias et al. 2015). Finally, the presence of tourism may be more broadly indicative of the potential for economic diversification and adoption of new livelihood opportunities.

Country-level examples

Current legislation restricts all targeted shark fishing within Myanmar's EEZ. Yet given the socioeconomic challenges presented in the Challenge Index (Myanmar ranks 15/87), I predict that it would be challenging for a SLMPA in Myanmar to be successful in achieving shark biodiversity benefits. Myanmar is somewhat dependent on marine resources, presenting an opportunity to improve shark biodiversity through the establishment of legislation that reduces fishing pressure. The trade-off however, is a cost to livelihoods due to a fisheries-dependent economy. Low adaptive capacity related to low education levels and high economic vulnerability, in addition to high levels of corruption present challenges to addressing the trade-offs between livelihoods and biodiversity (Fig. 6). Myanmar is a country emerging from more than four decades of military rule amidst a background of political violence, and suppression of democratic opposition (Cockett 2015, Transparency International 2018). While general elections commenced in 2010 and steps are being taken towards economic and political reform, Myanmar continues to face challenges of endemic corruption, consistently ranking towards the bottom of the Corruption Perception Index (Transparency International 2018). Delving further into Myanmar's socioeconomic profile, there are increasing numbers of people concentrated in coastal areas (Dearden 2016). In-migration has doubled each decade between 1980 and 2009 at major fishing communities, with most migrants searching for improved livelihood opportunities from fishing (Schneider and Thiha 2014, Dearden 2016). Shark markets continue to operate within the country (Howard et al. 2015), and given the socioeconomic challenges presented in the Challenge Index, it is unsurprising that Myanmar's shark fishing ban is failing (Howard et al. 2015). High level decision makers in Myanmar might need to consider alternative approaches to shark conservation by directing efforts and funding towards development, and reducing local demand for shark products in order to create socioeconomic foundations that are resilient to restrictions on fishing, and subsequently a population that is more likely to comply with restrictive legislation.

In the case of the Maldives Shark Sanctuary, a high score on the Opportunity Index (rank 1/87) as a result of lower corruption levels and higher potential for tourism presents opportunities for successful implementation of a SLMPAs (Fig. 6). Tourism in the Maldives accounts for 76.6% of the GDP (KNOEMA 2017), with 43.2% of GDP directly related to reef tourism (Spalding et al. 2017). Furthermore, shark related tourism expenditure is increasing which has made a strong economic case for shark conservation in the Maldives (Cisneros-Montemayor et al. 2013, Cagua et al. 2014). This positive situation is enhanced by the fact that whale sharks (*Rhincodon typus*) are year- round inhabitants of the Maldives, providing further opportunities for shark-focused wildlife tourism (Cagua et al. 2014). Moreover, a high degree of shark related management measures have been implemented in the Maldives (i.e. finning restrictions, a National Plan of Action for Sharks, signatory to the Convention on the Conservation of Migratory Species and party to the Port State Measures Agreement) creating a strong foundation for guiding effective governance of the Maldives Shark Sanctuary.

Interestingly, there was evidence of only a weak linear relationship confounded by multiple outliers (Fig. 4) between the Challenge and Opportunity indices, highlighting the complex reality that opportunities for conservation will often co-exist with challenges to resource users. Areas with the greatest potential for biodiversity impacts are in places where dependence on fishing is high, and removing those pressures presents challenges related to negative impacts to livelihoods. To illustrate, while the Maldives (an outlier) was high on the Opportunity Index, it also ranked 6th on the Challenge Index, indicating the presence of certain livelihood and biodiversity trade-offs associated with implementing SLMPAs. The Maldives has significant dependence on marine resources: marine fisheries accounts for 11.31% of the national GDP (Pauly and Zeller 2015) and small but significant proportion of fishers engaged in shark fisheries (M.R.C. 2009, Ali and Sinan 2015). This dependence on marine resources coupled with high economic vulnerability suggests that fishers in the Maldives have fewer resources to adapt to economic changes such as reduced income from fishing. However, these characteristics are typical of most developing coastal nations within which > 90% of those people employed by capture fisheries reside (World Bank 2012). If SLMPAs are to have impact, biodiversity benefits will always encounter some degree of challenge with respect to detriments to livelihoods, highlighting the importance of building adaptive capacity across all nations in which shark conservation is a priority. While I can be generally optimistic about the opportunities for the Maldives current Shark

Sanctuary to benefit biodiversity and potentially livelihoods through tourism and other opportunities, supporting livelihood diversification for resource-dependent fishers and their families, and ensuring equity in regards to tourism benefits should be a priority in order to limit costs to local communities. Moreover, it is important to note that alternative livelihood initiatives are not a panacea for resolving problems arising from restriction of resource access. Since local communities are subject to many of the socioeconomic challenges highlighted in this paper, failure to consider local context could also result in their failure to achieve the intended outcomes of SLMPAs (Gillet et al. 2008).

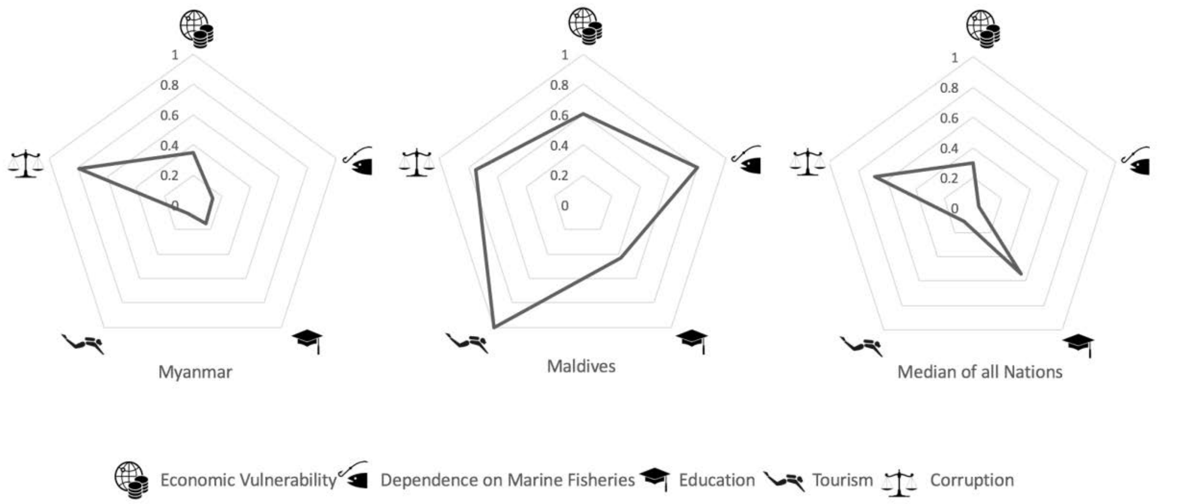


Figure 6. Standardised socioeconomic attributes of Myanmar and the Maldives, compared to the median of 87 low income and least developed coastal nations.

Implications for policy makers

While the indices presented in this study provide context for shark conservation interventions, these can be most beneficial when used alongside biophysical considerations such as location of threatened shark species (Davidson and Dulvy 2017), and movement and migration patterns (Green et al. 2015, Brodie et al. 2018). This more holistic approach to understanding a nation's socioeconomic and biophysical characteristics will allow policy makers to make well-informed decisions about conservation based on socioeconomic and biophysical factors, tailored to each nation's unique context.

Though this study provides national scale context for planning SLMPAs, it is important to recognise that the socioeconomic factors that form these indices are not homogenous throughout each nation, and local context will be fundamentally important in finer scale conservation planning. While this heterogeneity indicates that I should not expect these indices to be useful at local scale MPA planning, the Opportunity Index can recommend when national-scale conservation approaches to initiate shark conservation should be considered, while the Challenge Index can recommend when community-level conservation strategies may be a more appropriate approach. In such circumstances, conservation practitioners may wish to focus on more local-level socioeconomic factors such as local leadership, distance to market, traditional tenure and taboo areas, population size of village and important local fisheries (Mizrahi et al., 2018), that were outside the scope of this study. Diverse, context-specific approaches to shark conservation at a local level will be profoundly important to those nations in which SLMPAs are not deemed appropriate (Jones et al. 2013). Furthermore, I recognise that drivers for shark fishing do not operate in national isolation, and shark fisheries are strongly influenced by a global market for shark products. Therefore, conservation practitioners should also consider where a country falls on the international shark supply and demand chain, as this will influence local support for SLMPAs.

Finally, the indices that emerged from this study were solely obtained for least developed and low income countries, for whom the livelihood trade-offs resulting from SLMPAs will be most apparent. Trade-offs presented in my indices are therefore less relevant in the context of developed and high income nations, as it would be expected that such nations would have low Challenge and high Opportunity indices, and thus could support the successful implementation of SLMPAs. However, high income and developed nations also have the greatest ability to implement effective management measures to achieve sustainable fishing (Simpfendorfer and Dulvy 2017), and hence may have less need for such initiatives. Other lines of discourse focused on including socioeconomic considerations into managing sustainable shark fishing may therefore be more relevant in a developed context.

Conclusion

Shark large MPAs have the potential to provide conservation benefits to sharks. Yet, one of the primary reasons that SLMPAs are failing to have positive impacts on biodiversity is that the socioeconomic context in which they operate is not always considered during the planning process. This study used national-level socioeconomic data to highlight the challenges and opportunities associated with implementing SLMPAs in developing countries. These indices identified nations in which socioeconomic conditions are favourable for SLMPAs to be successful in providing conservation benefits to sharks, and those in which other shark conservation measures may be more appropriate. Highlighted within these indices are trade-offs between benefits to biodiversity and costs to livelihoods that exist because, for SLMPAs to have positive biodiversity impact, resource use must be restricted, and costs will be borne by local users. While these costs may be manageable in contexts where governance is strong and fair, and opportunities are available for livelihood diversification, many developing nations are not socially or economically positioned to deal with the restrictions associated with SLMPAs. In combination with biophysical considerations, my Challenge and Opportunity indices can support high-level policy makers to decide whether, and in what cases, SLMPAs are the most appropriate measure to provide conservation benefits to sharks. In circumstances where SLMPAs are not deemed appropriate, policy makers could focus efforts on reducing socioeconomic challenges through avenues such as livelihood development and fisheries management, in order to minimise costs to resource users, and maximise the likelihood that future conservation initiatives will be supported.

Chapter Three Summary

Chapter 3. Global opportunities and challenges for Shark Large Marine Protected Areas

Abstract: Legislation to ban the targeted fishing of sharks is frequently employed within developing coastal nations. These Shark Large Marine Protected Areas (SLMPAs) are established primarily to alleviate the direct threats that humans pose to sharks through activities such as overfishing and destructive fishing practices. However, despite the anthropogenic nature of these threats, socioeconomic factors are often given less consideration than their ecological counterparts when designating SLMPAs. In this paper, we identified and examined relevant national- level socioeconomic data to determine the challenges and opportunities associated with implementing SLMPAs, focusing on least developed and low income countries. We aimed to use these socioeconomic data to identify nations where SLMPAs are more likely to be successful in providing conservation benefits to sharks. We used principal component analysis to develop two national-level indices that represent these anticipated opportunities and challenges for implementing SLMPAs across 87 coastal nations. The Opportunity Index identifies those nations in which socioeconomic conditions such as adaptive capacity, and strong and fair governance, are favourable for SLMPAs to provide conservation benefits to sharks. The Challenge Index identifies those nations that may not yet be in a position developmentally to support communities to adapt to a loss of access to resources associated with SLMPAs, or to manage and enforce broad scale restrictive legislation. In combination with biophysical considerations, the Challenge and Opportunity indices presented here can support policy makers in deciding whether, and in what cases, SLMPAs are the most appropriate measure to provide conservation benefits to sharks.

Mizrahi, M., Duce, S., Pressey, R.L., Simpfendorfer, C.A., Weeks, R., Diedrich, A. (2019). "Global opportunities and challenges for Shark Large Marine Protected Areas." Biological Conservation **234**: 107-115.

Chapter Four. Small-scale fishers risk falling short amid economic and environmental reforms: a case study from Myanmar's Myeik Archipelago

Chapter Four. Small-scale fishers risk falling short amid economic and environmental reforms: a case study from Myanmar's Myeik Archipelago

Forward

I was first introduced to Myanmar's small-scale fishing communities in 2017, when I was invited to partake in an MPA Policy workshop while working for Fauna and Flora International. This laid the foundations for my selection of Myanmar for the local-scale case study of my research and gave me the opportunity to continue to support Myanmar in their MPA development process. Over the past three years, I have spent many months in Myanmar's coastal communities in both the Tanintharyi and Rakhine coast, for my research and work. I now live in Yangon, Myanmar where I work as the Marine Technical Advisor to the Wildlife Conservation Society and continue working on MPA development. This chapter, and the fieldwork that supported it, has cultivated my understanding of the critical challenges facing the small-scale fishing communities I now work with. This chapter is currently in review in *Marine Policy*[3].

Introduction

In Myanmar, marine resources are a major contributor to food security, providing direct livelihoods to an estimated 1.4 million fishers (DoF 2017), with per capita consumptions among the highest in the world (FAO 2017). While a large proportion of these livelihoods is attributed to small-scale fishers, Myanmar's small-scale fishing communities remain poorly understood (Butcher 2004). Furthermore, these fisheries are ill-documented; almost none of the literature on rural areas during Myanmar's military rule relates to small-scale fisheries, and little is known of their contemporary status (Tezzo et al. 2018).

As Myanmar emerges from five decades of political and economic isolation, small-scale fishers are increasingly vulnerable to human-related environmental threats that result from poor regulation, inadequate legislation, and ineffective law enforcement, including the uncontrolled expansion of fishing effort, illegal fishing, in-migration to fishing communities, and conflicts over land use (Schneider and Thiha 2014, Dearden 2016, Ya 2016). For example, the introduction of trawling in the 1980s has resulted in ongoing conflicts between small-scale and industrial fleets (WCS 2018). While current legislation prohibits trawlers from fishing in-shore (within 18 km from the coastline), these laws are largely ignored, or not enforced by governing authorities (WCS 2018). Pelagic and demersal fish stocks

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[3] Mizrahi, M. i., S. Duce, Z. L. Khine, T. MacKeracher, K. M. C. Maung, E. T. Phyu, R. L. Pressey, C. Simpfendorfer and A. Diedrich (in review). "Small-scale fishers risk falling short amid economic and environmental reforms: a case study from Myanmar's Myeik Archipelago." Marine Policy.

have subsequently decreased throughout Myanmar's exclusive economic zone to 10% of their 1979 biomass, with similar estimates for inshore coastal fisheries (Krakstad et al. 2014).

Small-scale fishers in Myanmar are also vulnerable to changes resulting from a national economy that is globalising amid a backdrop of reforms initiated in 2011 (Prescott et al. 2017, Tezzo et al. 2018). Significant investments are being made into offshore oil and gas, aquaculture, tourism, shipping, and commercial fisheries, which are likely to further compromise local marine ecosystems, and thus the livelihoods of small-scale fishers that they support (Clifton et al. 2018). Furthermore, coinciding rapid political transformation has brought Myanmar to a crossroads in terms of how to approach governance of natural resources (Prescott et al. 2017). The Government of Myanmar is increasingly making commitments towards marine protected areas (MPAs), indicating its commitment to conserve at least 10% of coastal and marine areas, in line with the Aichi Targets (CBD 2010), and making a high-profile public commitment to MPAs and marine spatial planning during the 2017 and 2019 Our Oceans Summits (OOC 2017, OOC 2019). While these commitments indicate some government intent towards safeguarding marine environments, there is little understanding of what the repercussions will be for small-scale fishers residing in affected areas.

In recent years, Myanmar's terrestrial protected areas have been at times poorly received by communities, with conflicts over land-use arising between indigenous ethnic groups and enforcing parties (see CAT 2018). Moreover, Myanmar's strong military history has resulted in ongoing mistrust between communities and government institutions (Einzenberger 2016, Wilson 2017, CAT 2018). As Myanmar's government moves forward with MPA planning, better understanding of the particular social context within which MPAs are to be implemented will be essential to build trust, increase likelihood of compliance with MPA regulations, and mitigate negative livelihood impacts on local fishers (Berkes 2001, Leenhardt et al. 2015, Thiault et al. 2017).

In general, small-scale fishers across the globe tend to be similarly anchored in local communities, reflecting historic links to marine resources, traditions and values (Tunstall 1969, Van Ginkel 2001, Pollnac and Poggie 2008, Urquhart and Acott 2014). However, more nuanced characteristics of small-scale fishing communities generally vary depending on location (FAO 2015) and social subgroup (Gurney et al. 2015). This is true of Myanmar's southern Myeik Archipelago, where small-scale fishing communities are complex, encompassing multiple languages, ethnic groups, and varying links to the environment (Schneider and Thiha 2014). Given the ethnically heterogeneous nature of these communities, incorporating their varied needs into MPA planning will be challenging due to a lack of community cohesion and shared traditional value systems typical of more ethnically homogenous communities (Gurney et al. 2015). As the country continues to transition towards increased MPAs, a dearth of empirical studies characterising Myanmar's small-scale fishing communities reflects a situation whereby small-scale fishers in the Myeik Archipelago are potentially vulnerable.

Vulnerability, in the context of social change, can be defined as the state of susceptibility to harm from perturbations (Adger 2006). The potential vulnerability of small-scale fishers in relation to a proposed MPA can be characterised, in part, through socioeconomic factors such as age, wealth, livelihood diversity, and education level (Cinner et al. 2009, Cinner and Bodin 2010, Launio et al. 2010, Setiawan et al. 2012, Gurney et al. 2015, Voyer et al. 2015 in Mizrahi et al. 2018). As fishers age, opportunities to diversify livelihoods decrease (Cinner et al. 2012), as does willingness to gain new environmental knowledge (Gurney et al. 2015). Fishers who are most wealthy will often be most influential in local government and thus position themselves to benefit from management decision making (Adger and Kelly 1999, Christie 2004). Wealthy fishers also face fewer risks associated with attempting a new livelihood activity if access to fisheries resources is restricted (MacNeil and Cinner 2013). Furthermore, livelihood diversity, education and wealth provide a strong indication of occupational diversity and flexibility (Cinner et al. 2009). Occupational flexibility is also a key element that influences people's vulnerability to natural and economic shocks in social-ecological systems (Adger 2000) and their ability to circumvent poverty traps.

Regulations such as top-down MPAs can be difficult to implement if they are seen to restrict activities that support general wellbeing (Ostrom 2007) or if fishers are so strongly linked culturally or traditionally to fishing that investigating alternative livelihood strategies is unrealistic (Pollnac and Poggie 2008, Seara et al. 2017). 'Bottom-up' traditional management approaches have been touted in Myanmar as an alternative to more centralised approaches of marine management (Dearden 2016). These traditional management tools typically stem from local practices and beliefs, and can manifest in gear restrictions, seasonal or temporal harvesting restrictions, and periodic closures (Cinner et al. 2005, Pollnac and Johnson 2005). While likely to have evolved as social or cultural tools (Foale et al. 2011), more contemporary adaptations (e.g. community-based management areas) have been shown to support livelihoods, conserve biological diversity, and safeguard against negative effects of climate change (Govan 2009, Bartlett et al. 2010).

In most places where traditional management has been successful, fishers typically hold land tenure, cultural ties to fishing grounds, historic linkages to fishing, and/or have strong community cohesion (Cinner et al. 2006, Weeks and Jupiter 2013). These conditions are not typical of the Myeik Archipelago where in-migration from the mainland to island communities has increased over the past decade, with new migrants seeking increased livelihood opportunities from fishing (Schneider and Thiha 2014). In these contexts, cultural and bequest values associated with marine resources might not yet exist, and challenges might arise when implementing fishing restrictions if a previous reference point for fisheries has not yet been established (Foale and Dyer 2016). While new migrants might have less established relationships with marine areas, others could be more culturally or historically linked to locations, and experience fishing as a 'way of life' rather than solely a means of income (Pollnac and Poggie 2008, Seara et al. 2017). Furthermore, in plural societies typically of Myanmar (Cockett 2015), cultural practices are not homogenous, meaning that traditional management approaches will have to consider multiple and sometimes conflicting set of values held by multiple ethnic groups in each community.

Given the heterogeneous ethnic makeup of the Myeik Archipelago's small-scale fishing communities, it is likely that the aforementioned factors influencing fishers' vulnerability to fisheries resources restrictions due to MPAs will vary depending on ethnic subgroup. Research has shown that sociocultural complexity is a key limiting factor for the progress rate of community-based management areas (Crawford et al. 2006). Therefore, whether approached from the top-down or bottom up, there is an essential need to understand the local context of fishing communities within the Myeik Archipelago, including the varying social and cultural ties to fishing.

In this study, I characterise three small-scale fishing communities in a relatively under-researched region in Myanmar's Myeik Archipelago. Face-to-face interviews and participatory mapping exercises in these poorly studied communities were conducted, and I explored how ethnic heterogeneity might influence the capability of fishers to respond to different natural and economic shocks to social-ecological systems, such as new political, economic and environmental reforms.

Methodology

Study Site

This study took place in the Thayauthadangyi and Lampi island groups within the Myeik Archipelago, in the southern coast of Myanmar's Tanintharyi Region, bordering Mong State to the north and Thailand to the south (Figure 7). The archipelago consists of more than 800 granite and limestone islands, and is recognised as a Key Biodiversity Area of global importance (BLI 2018). Most islands are covered with lowland wet evergreen forest with shorelines of sandy beaches and rocky headlands. Mangrove forests and mud flats dominate the more sheltered, inner islands. The marine environment supports diverse fringing coral reefs, seagrass meadows, and mangrove forests (Howard et al. 2015). Islands within the archipelago are largely uninhabited. This study focused on two communities in Thayauthadangyi, Don Pale and Lin Long, and one community on Lampi Island, Makyone Galet. Infrastructure and basic public services are limited in all communities, and the main livelihood strategy in all communities is fishing (Beffasti and Theint 2010, Schneider and Thiha 2014). According to the 2014 census, 1650 people live in Don Pale, and 689 in Lin long (Schneider and Thiha 2014). Makyone Galet is the only official village on Lampi Island, while other residents live in private work camps or temporary fishing camps. Approximately 700 people live in Makyone Galet (2018 census data).

The human populations in the Myeik Archipelago are almost entirely comprised of Bamar, Karen and Moken ethnic groups. Bamar are the largest ethnic group in Myanmar accounting for 68% percent of the population, following Buddhist practices and constituting the largest proportion of the central government (Kipgen 2015). Karen constitute the second largest ethnic group in Myanmar and, while the majority are Buddhist, a significant minority in coastal areas converted to Christianity during colonisation. Finally, the Moken peoples are semi-nomadic 'sea-gypsies' who are considered the most marginalised of the three groups (Schneider and Thiha 2014). Moken people have been living in the Myeik Archipelago since at least the 18^{th} century, and their range stretches from the Myeik Archipelago to the south of Thailand in the Andaman Sea (Schneider and Thiha 2014). During the past 20 years the Moken peoples have become more settled with permanent villages across the archipelago but still rely almost exclusively on marine resources for their livelihoods (Schneider and Thiha 2014). There are currently only an estimated 1,630 Moken left in the archipelago (Thar and Dunant 2019).

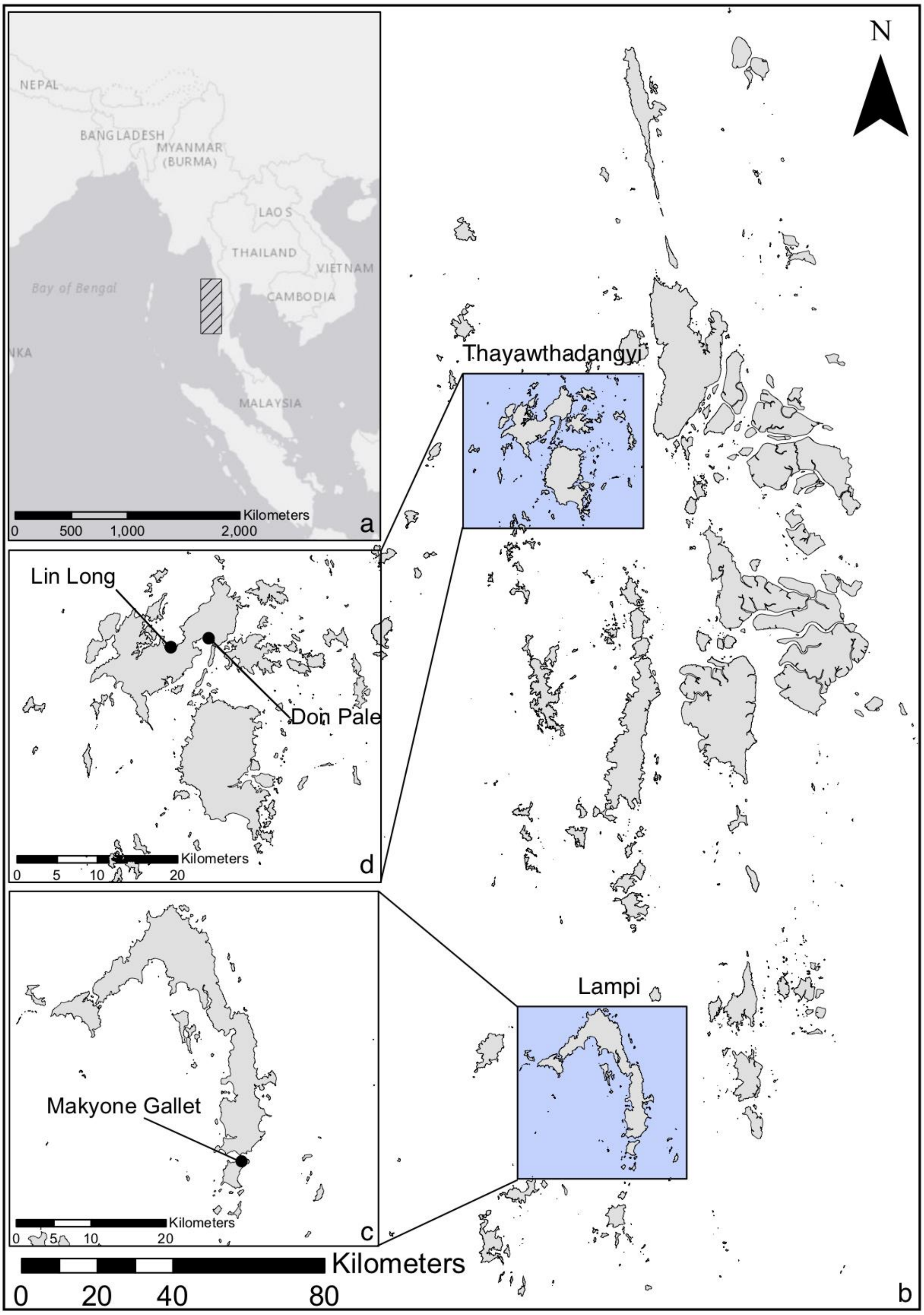

Figure 7. Maps of the Myeik Archipelago highlighting three study sites in Don Pale, Lin Long and Makyone Gallet.

Map a: Myanmar in a regional context highlighting the Myeik Archipelago; Map b: The Myeik Archipelago; Map c: Lampi island group; Map d: Thayawthadangyi island group.

Data Collection

Data were collected during November and December, 2017. Surveys were carried out by marine science research staff from Myeik University, all of whom were trained in socioeconomic data collection and participatory mapping methods. The survey questionnaire was trialled in Myeik Township with fishers from mainland Myanmar to ensure interpretability of the questions. Interviews were conducted in Burmese language, or local Moken dialects through an additional translator. Within the three villages, researchers conducted a series of structured, face-to-face surveys with active, mobile fishers to obtain qualitative fisheries data, quantitative data on factors that represented key indicators of vulnerability, and levels of satisfaction with life and fishing. A participatory mapping exercise with each fisher identified the location of their three most frequented fishing grounds on a satellite image of the Myeik Archipelago, and the fishers estimated how long (on average) it took them to get there. For these exercises, participants were also asked a series of questions pertaining to the spatial and temporal characteristics of their fishing grounds, their home village, and various other landmarks within the Myeik Archipelago to ensure their conceptualisation of the seascape and map were aligned. Fishers were targeted through a combination of intercept approach at locations where they gathered, and subsequently via snowball sample. While a total of 120 participants were interviewed, I excluded incomplete datasets, leaving a total of 111 fishers (Male to Female Ratio= 8.6:1.4) contributing to this study (Don Pale n=39; Lin Long n= 43; Makyone Gallet n=29). Fewer females were interviewed, as cultural norms in Myanmar mean that active, mobile fishing roles are dominated by men, while women play a larger roles in pre- and post-harvesting activities (Angeles et al. 2019) . I included participants from all three ethnic groups (Don Pale: Moken=4; Barmar=20; Karen=15; Lin Long: Moken=0; Barmar=5; Karen=38; Makyone Gallet: Moken=19; Barmar=7; Karen=3). A full outline of the survey is in Appendix 3.

Indicators for Vulnerability

To develop a framework for assessing vulnerability I included four socioeconomic factors related to age, livelihood diversity, education level, and material style of life (MSL). These have been broadly identified in the literature as factors that influence how MPAs impact on livelihoods (see Chapter Two). These factors are not intended to represent all components of vulnerability, but instead to measure some aspects relative to vulnerability of small-scale fishers in relation to restricted access to fisheries resources. The premise of this framework is that *low* vulnerability to restricted access to fisheries resources requires: 1) sufficient number of working years ahead to develop new skills and applicable knowledge (i.e. age), 2) multiple livelihood strategies (i.e. livelihood diversity), 3) skills to take on new livelihood opportunities (i.e. education), and 4) financial security against restrictions on resource extraction (indicated by MSL).

MSL was represented by a principal component score of household items of the individuals (Pollnac and Crawford 2000). Indicators concerning respondents' levels of satisfaction with fishing and life in general were assessed using a 10-point Likert scale ranging from the worst- and best-case scenarios for each indicator.

Analysis

Between ethnic groups I compared fisheries characteristics of target species, gear type, and distance travelled to fisheries ground. Fishing sites were georeferenced using ESRI ArcGIS 10.2.2 software with each individual polygon attributed to an individual fisher and their associated gear and catch. The *Union* and *Spatial Join* tools were to quantify the number of fishers who used each area and to calculate the attributes of all fishers who operated in each area. I calculated Euclidean distance from the central point of each fishing site to the fisher's village. Kruskal-Wallis H test was conducted to determine if there was a significant difference between distance travelled to fishing ground based on ethnic group.

We compared vulnerability indicators across ethnic groups, and also explored the relationship of MSL with levels of life and fishing satisfaction for each ethnicity. Using SPSS 25.0.0.0, I conducted a Kruskal-Wallis H test to determine if age, education, livelihood diversification, or MSL of fishers differed among ethnicities. Spearman's correlation analysis was computed to assess the relationship between life satisfaction and fishing satisfaction, and life satisfaction and MSL. I used a Kruskal-Wallis H test to determine if there were differences in fishing satisfaction, life satisfaction, and MSL among ethnicities.

Results & Discussion

Fisheries Characteristics

Communities within the Myeik Archipelago operate within a multi-species, multi-gear fishery, influenced largely by seasonal changes. Overall, fishers employed five different fishing gears and targeted 26 different species. The most frequently used fishing gears were hand lines, nets and spearfishing via compressor diving, while the most commonly targeted species were stingrays, fusiliers and squid/cuttlefish. Moken fishers were more likely to use traditional methods of fishing such as hand line, compared to Karen and Bamar fishers who employed more modern technologies such as nets and spearfishing via compressor diving. Bamar fishers mostly targeted stingrays, squid and rabbitfish; Karen fishers mostly targeted stingray, rabbitfish and fusilier, and Moken fishers mostly targeted squid, chiton and stingray. Catch was either sold to middlemen/travelling buyers, at nearby landing sites on the mainland, or kept for local consumption.

Across all three ethnic groups, most fishers chose their fishing grounds based on proximity to the village, ease of travel there, presence of sheltered waters, or abundance of target species. Moken fishers frequently stated that they chose their sites because it was 'theirs'. Fishing grounds were a reported at an average of five hours away from the village of origin (SD=5.14). In general, fishers travelled further during the dry season (October to May), (Euclidean distance m=20.95 km, SD= 11.77; mean travel time=6.30 hours, SD=5.98), and stayed closer to home during the wet season (June to September), (Euclidean distance m=11.60 km, SD=15.82; mean travel time =4.10 hours, SD=3.19). Euclidean distance showed that, on average, Bamar fishers were likely to travel furthest to their fishing grounds (m=19.98 km, SD=21.83), followed by Moken fishers (m=18.38 km, SD= 10.83), and Karen (m=6.67 km, SD= 5.69).

Moken fishers were the only ethnic group to refer to a perceived ownership of their fishing grounds. While the use of traditional fishing gear and perceived sea tenure supports the romantic notion of subsistence 'sea gypsies' often associated with Moken fishers, it also emphasises the increased challenges that this group will face if new reforms restrict them from fishing within their grounds. These historical links are not formalised through law, and while Moken now have citizenship cards, they lack documentation that could prove tenure. Forced resettlement has already been seen in some parts of the Myeik Archipelago, where the increased presence of lucrative, privately owned pearl aquaculture in Moken fishing territory has resulted in the displacement of Moken from their fishing grounds (Thar and Dunant 2019). As Myanmar modernises with increased investments into aquaculture and commitments towards MPAs, displacement could increase unless specific rights are formalised for Moken fishers.

Vulnerability Indicators

The Kruskal-Wallis H test showed livelihood diversification was significantly lower for Moken fishers, compared to Bamar and Karen fishers (H(2)=18.00, p=<001) (Table 1). Education levels were also significantly lower for Moken fishers compared to Karen and Bamar fishers (H(2)=41.74, p=<0.001). Moken and Karen fishers were significantly younger in age compared to Bamar fishers (H(2)=9.25, p=0.01). There was no significant difference in MSL between Bamar, Karen and Moken fishers, (H(2)=0.778, p=.678).

Low levels of livelihood diversity coupled with low education across all ethnicities (Table 7) indicate that dependence on fishing is strong in the Myeik Archipelago and that most small-scale fishers will require significant support if resource access is restricted by new reforms that affect Myanmar's marine seascape. With livelihood diversification and education levels highest for Bamar and Karen fishers, these ethnic groups might be less risk-averse to explore new livelihood opportunities, and better equipped to adapt to potential restrictions on fishing (Gurney et al. 2015). Variable levels of education within these communities could manifest as elite capture, whereby elites, in this case the most educated majority, use their positions of power to promote their own interests at the expense of others (Béné et al. 2009). Given the variable levels of education in fishing communities in the Myeik Archipelago, the impacts of Myanmar's new reforms are likely to vary among fishers depending on their positions of power within each community. The most educated are more likely to position themselves such that they are influential in policy-related decision-making and benefit from local government arrangements (Adger and Kelly 1999, Christie 2004). The remaining fishers, especially the Moken population, are likely to need more time to adapt to new reforms, and support might be required to bring their voices to the decision-making table (MacNeil and Cinner 2013).

If new reforms in Myanmar result in restrictions on fishing activities, communities in the Myeik Archipelago are likely to also require further investments into education, diversification of livelihoods, and forums to foster ecological knowledge. This is particularly true for Moken fishers, who consistently have lower education levels and livelihood strategies compared to Bamar and Karen fishers. Moken fishers also face additional barriers such as language and cultural prejudice which could limit dialogue with policy makers who shape natural resource management (Cohen et al. 2019). While new commitments towards management of marine resources (e.g. MPAs) have the potential to improve livelihoods of small-scale fishers and indigenous groups (Christie et al. 1994, Himes 2003, Mascia et al. 2010), particular attention should be payed to consulting with Moken fishers, together with acknowledgment of the historic and cultural ties between the Moken and the Myeik Archipelago through interventions such as the allocation of specific fishing rights to Moken fishers. A failure to recognise the vulnerability of Myanmar's Moken population could result in harmful repercussions, adding to the accrual of indigenous and minority groups in Myanmar who have been disadvantaged by poorly planned protected areas (Aung 2017, CAT 2018) or non-inclusive governance systems (OHCHR 2019).

Satisfaction with life and fishing

Across all communities, there was a significant positive correlation between fishing satisfaction and life satisfaction ($r=0.712$, $p=<0.001$) (Table 1). However, there was no significant correlation between wealth (as described by MSL) and fishing satisfaction ($\boldsymbol{r}=.171$, $p=0.137$) or wealth and life satisfaction ($\boldsymbol{r}=0.081$, $p=.481$). For those participants unsatisfied with fishing as a means of livelihood (50 participants gave a score of ≤ 5 of 111), the main reasons given were that fish were declining, fishing was dangerous, and income was uncertain.

My results indicate that, for most small-scale fishers in the Myeik Archipelago, fishing is potentially a more important factor in influencing life satisfaction compared to wealth, and that small-scale fishers in Myeik derive a particular proportion of their wellbeing from fishing. This is congruent with wider studies illustrating that occupational satisfaction is a significant component of individual and community wellbeing (Pollnac and Poggie 2008, Seara et al. 2017). Of all the ethnic subgroups in this study, Moken fishers had the greatest satisfaction with life, despite having the lowest levels of MSL. Additionally, when fishers were asked if they had to live their lives over, whether they still be a fisher, 65% of Bamar respondents and 59% of Karen respondents said no, whereas only 15% of Moken respondends said no, further reflecting special cultural ties to fishing. For many Moken fishers, fishing might be so entrenched in identity that expecting them to comprehend an alternative occupation could be unrealistic. I consider the aforementioned useful, given that Myanmar is now making increased commitments towards protecting marine environments through MPAs. Traditional methods of supporting small-scale fishers through the transition of resource restriction, such as through encouraging alternative livelihood activities, might not be appropriate for some subgroups if their identities are deeply bound to fishing. Furthermore, alternative livelihood strategies have often failed in developing countries (Sievanen et al. 2005), with poverty and age being key obstacles (MacNeil and Cinner 2013). For Moken fishers, the combination of these characteristics, coupled with a strong identity that aligns with fishing, suggests a group of people who will have particular problems in adapting to restrictions to fishing practices associated with new policy reforms. Careful and considerate engagement with Moken fishers will therefore be vital to safeguard local livelihoods, and to ensure that cultural values associated with fishing are maintained. Public participation in political decision-making is widely advocated in academic literature, as a means to build public trust and support for government and decision makers (CBD 2010, FAO 2015, Day 2017, Giakoumi et al. 2018). As Myanmar takes steps towards democratic restructuring, participation should be prioritised. Meaningful stakeholder engagement will be imperative to build trust and avoid conflict with the most vulnerable small-scale fishers, and to learn from past mistakes in excluding local and indigenous resource users from decisions about natural resource management (Aung 2017, CAT 2018).

Table 7.Socioeconomic characteristics related to the vulnerability of fishers separated by ethnicity.

Category	**Ethnic group: Mean (Standard Deviation)**		
	Bamar (N=32)	Karen (N=56)	Moken (N=23)
Age	45 (15.2)	35 (11.9)	34 (14.4)
Livelihood diversification (total number of different occupations per individual)	1.3 (0.47)	1.7 (0.51)	1.2 (0.37)
Education level (number of formal schooling years completed per individual)	4.7 (2.96)	4.66 (2.65)	0.15 (0.67)
Material style of life (factor score of household items of the individual (Pollnac and Crawford 2000) (see Appendix 4)	0.62 (0.29)	0.59 (0.32)	0.57 (0.31)
Fishing satisfaction (individual ranking on a scale of 1-10 of level of satisfaction with fishing as a livelihood)	6.32 (2.43)	5.88 (2.44)	6.56 (2.53)
Life satisfaction (individual ranking on a scale of 1-10 of level of satisfaction with life in general)	6.75 (2.37)	5.99 (2.22)	6.89 (2.75)

Conclusion

Myanmar's small-scale fishers currently face an uncertain future amid a backdrop of political reforms centred on a globalising economy and increased commitments towards MPAs. Results from this study assert that ethnic heterogeneity in the Myeik Archipelago could present a unique challenge to implementing environmental reforms, and that certain sub-groups are likely to be margenalised if their diverse needs are not considered. Whilst new policies offer the potential to support fisheries production through better managed resources, a failure to recognise the heterogeneous community context, including varying levels of vulnerability and linkages to fishing as an identity, could adversely impact Myanmar's most vulnerable small-scale fishers. In this time of political and economic transition, careful consideration of the livelihood needs of small-scale fishers in the Myeik Archipelago is needed to ensure that stakeholders are engaged with the decision-making process. Particular attention should be given to supporting the rights of indigenous Moken fishers, to ensure that traditional and cultural fisheries values are safeguarded for generations ahead.

Chapter Four Summary

Chapter 4. Small-scale fishers risk falling short amid economic and environmental reforms: a case study from Myanmar's Myeik Archipelago

Abstract: Myanmar's small-scale fishers currently face an uncertain future amid a backdrop of policy reforms centred on a globalising economy, and increased commitments towards marine protected areas. As Myanmar continues to transition towards policy reforms, a dearth of empirical studies characterising Myanmar's small-scale fishing communities reflects a situation in which small-scale fishers are potentially vulnerable. Here, we provide a characterisation of three small-scale fishing communities in Myanmar's Myeik Archipelago. We conducted interviews and participatory mapping exercises to characterise these communities, and explored how variations among ethnic groups influenced fishers' capability to respond to natural and economic shocks to social-ecological systems. Results from this study reflect a group of multi-species, multi-gear fishing communities, that are influenced largely by seasonal changes. Modernity of fishing technologies differed among ethnic group, as did socioeconomic characteristics such as livelihood diversity, education levels, and cultural ties to fishing. These attributes revealed Moken fishers are a more vulnerable population who also face barriers such as language and cultural prejudice, which may limit dialogue with policy makers who determine strategies for natural resource management. Results indicate that ethnic heterogeneity in the Myeik Archipelago could present a unique challenge to implementing environmental reforms, and that certain ethnic groups are likely to fall short if their needs are not taken into consideration. Whilst new policies offer the potential to support fisheries production through better managed resources, a failure to consider the heterogenous nature of Myanmar's small-scale fishing communities could result in changes that adversely impact some of Myanmar's most vulnerable people.

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Chapter Five. Mitigating negative livelihood impacts of no-take MPAs on small-scale fishers

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Forward

Small-scale fishers often incur negative and disproportionately adverse impacts from MPAs. This chapter uses a participatory mapping approach to generate a tool for designing MPAs that minimize negative impacts of MPAs on vulnerable individuals. Since I began working in applied conservation six years ago, I have used participatory mapping as a key support tool for designing small-scale MPAs in Myanmar. I am fond of this approach to MPA planning because it allows you to understand seascapes through the eyes of others, as well as exposing varied interpretations of time and space. The index that emerged from this chapter has significant practical implications for 'on-the-ground' MPA design and is currently being considered as a methodology for the Wildlife Conservation Society to use to support equitable MPA design in Tanzania and Cambodia. This chapter was published in *Biological Conservation*[4].

Introduction

Ninety-seven percent of small-scale fishers live in least developed countries (W.B. 2012). The value of marine resources to these fishers lies not only in employment and nutrition (Kawarazuka and Béné 2010, Kawarazuka and Béné 2011, Barnes et al. 2013), but also in cultural, social and bequest values, that operate synergistically in their contribution to fishers' wellbeing and livelihoods (Béné 2006, Salas et al. 2007, O'Garra 2009).

Since fish biomass caught from the world's oceans peaked in the late 1980s, global fish production has declined at an unprecedented rate (Pauly et al. 1998). Overexploitation of marine resources has resulted in adverse ecological consequences (e.g. Pauly et al. 1998, Cinner and McClanahan 2006, Januchowski-Hartley et al. 2015), and subsequent negative impacts on the livelihoods of many marine fishers (Clausen and York 2008). Negative impacts are amplified for small-scale fishers in developing countries who often operate in open-access and low-productivity fisheries, and are in perpetual competition with commercial fishing fleets for a shared marine resource (Andrew et al. 2007).

Galvanised by increasing pressure on marine fisheries and competition between resource users, international attention has focused on mechanisms to protect marine ecosystems while simultaneously seeking opportunities to support the sustainable use of marine resources. Marine protected areas (MPAs) have been endorsed as one means to achieve the dual objectives of biodiversity conservation

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and fisheries management (Roberts et al. 2001, Garcia et al. 2014). Over time, no-take MPAs can increase fish biomass, and “spillover” into adjacent open-access waters (NRC 2001, Topor et al. 2019). MPA zoning can also enhance food security for specific fishing subgroups by reallocating fishing rights which thereby reduces local competition for fishing re- source, such as the restriction of trawl vessels to allow only for artisanal fishers in certain zones (Christie et al. 1994, Himes 2003, Mascia et al. 2010).

While MPAs have the potential to benefit small-scale fishers, considerations concerning how capable local resource users are to adapt to MPA-related restrictions, and hence how vulnerable they are to negative consequences, are often overlooked (See Chapter’s One & Two) Vulnerability can be defined as the state of susceptibility to harm from perturbations (Adger 2006). A person's vulnerability is influenced in part by his or her ability to adapt to losses or alternations in resource access, and hence their potential to suffer negative con- sequences related to a change such as the establishment of an MPA (Adger and Vincent 2005, Gallopín 2006). While some individual fishers might be in a position to adapt to livelihood restrictions, others are more vulnerable to MPA-related restrictions due to socioeconomic limitations related to wealth, livelihood diversity, education and age (Cinner et al. 2009, Cinner and Bodin 2010, Launio et al. 2010, Setiawan et al. 2012, Gurney et al. 2015, Voyer et al. 2015). Fishers who are most wealthy are generally best placed to benefit from local government arrangements (Adger and Kelly 1999), and will often position themselves well in decision-making situations (Christie 2004). These fishers also experience fewer risks associated with attempting a new livelihood activity which serves as a safeguard if access to fisheries resources is restricted (MacNeil and Cinner 2013). In contrast, less wealthy fishers with fewer livelihood strategies and low education levels are generally most likely to be negatively impacted by restriction on fisheries resources, and are less likely to have the skills to attempt new livelihood opportunities (Cinner et al. 2012). Furthermore, as age increases, opportunities to diversify livelihoods decrease (Cinner et al. 2012), as does openness to gaining new environmental knowledge (Gurney et al. 2015).

Perversely, poorly designed MPAs often end up negatively impacting the most vulnerable people, who are most immediately affected by new regulations. Restricting the resource use of the most vulnerable can manifest in poverty traps, a reinforcing mechanism whereby people find it challenging to escape poverty unless a significant amount of economic capital is made available (Azariadis and Stach 2005). This is particularly true in least developed and low-income countries in which many of the world's small-scale fishers operate, and where fisheries provide one of the few opportunities for protein and income. For cases where small-scale fishers are not well placed to adjust to MPA-related changes, adverse impacts on vulnerable fishers can also result in ad- verse consequences for biodiversity, with fishers failing to comply with MPA regulations unless strong enforcement is present (Ostrom 2007). Potential biodiversity gains from MPAs are therefore less likely in cases where policymakers fail to consider the local needs and context of small-scale fishers. For example, responding to threats of over-exploitation and decline in fisheries, Thailand's government has implemented 16 National Marine Parks

(NMPs) within its Andaman Sea territorial boundaries (Bennett and Dearden 2014). While these NMPs were intended to support conservation, the parks are also situated in areas close to many of the 621 small-scale fishing communities that inhabit the Andaman coastline (Panjarat 2008). Local fishers were prohibited from harvesting in their usual fishing grounds, and one study of small-scale fishers in areas adjacent to the NMPs found that they felt they could not support themselves if they were excluded from fishing in those areas (Bennett and Dearden 2014). While Thailand's NMPs might contribute to national-level protected area targets (CBD 2010), local perceptions of these NMPs are mostly negative in small-scale fishing and subsistence harvesting communities, where fishing activities are generally seen to be adversely impacted by NMPs. These perceptions have resulted in protected areas with low compliance and hence limited biodiversity benefits (Prasertcharoensuk et al. 2010, Bennett and Dearden 2014).

In most studies that consider the livelihood needs of fishers in MPA planning, socioeconomic factors are included in the form of reducing livelihood costs of conservation to stakeholder groups as one homogenous entity, such as commercial fishers (Richardson et al. 2006), or entire communities (Thiault et al. 2018). When applied at a local scale, these methods become problematic because they assume there is no variation between costs to different individuals within each stakeholder group, and can lead to MPAs that have inequitable impacts on individuals. Inequitable distribution of costs and benefits within a com- munity can manifest as 'elite capture' whereby elites use their positions of status and power to promote their own interests at the expense of others (Béné et al. 2009). Due to the social and economic heterogeneity of many small-scale fishing communities, the impacts of MPAs are likely to vary among fishers depending on individual levels of vulnerability. Furthermore, fishers from the same community visit a range of fishing grounds influenced by factors including equipment available (e.g. access to a motorised vessels), time available, level of experience, and traditional values (unpublished data). This introduces further spatial complexity into whom within a community will be most affected by an MPA, and has, to the best of my knowledge, not been addressed in previous studies.

In this study, I aimed to develop a systematic method to identify the optimal location for no-take MPAs so that they limit negative impacts on small-scale fishers with the highest levels of vulnerability to experiencing negative consequences from MPAs (heron referred to as 'vulnerability') within a community. I designed a method for identifying these individuals based on four socioeconomic factors related to vulnerability, a key characteristic that mediates people's vulnerability to change (adapted from Chapter One), and applied this method in two socially and economically diverse communities in Myanmar's Myeik Archipelago. I used data collected from small-scale fishers in this area to represent each factor, then generated a local-level 'livelihood impact potential' index that reflects the degree to which a no-take MPA would impact an individual fisher's ability to support his or her livelihood. When this score is attributed to each fisher's most frequented fishing ground, the index can help identify locations where MPAs would be most detrimental to small-scale fishers' livelihoods based on their level of vulnerability.

Methods

Socioeconomic factors

Chapter One's systematic review identified 17 socioeconomic factors influencing the nature and level of impacts that MPAs have on livelihoods. In that study and the present one, impact is defined as the outcome resulting from protection compared to a counterfactual scenario of no protection (Pressey et al. 2015). From the initial list of 17 factors, I identified four local-level factors relevant to an individual's vulnerability to MPA restrictions: livelihood diversity, education, age, and wealth (Table 8). In combination, these measures indicate the degree to which individual small-scale fishers' livelihoods would be impacted by a no-take MPA. I used empirical data obtained from surveys with 80 fishers in the Myeik Archipelago to represent these factors (Table 8).

Study site

This study draws on data from three fisheries-dependent communities located in the Myeik Archipelago in Southern Myanmar: Don Pale, Lin Long and Makyone Gallet (Figure 7; Chapter Four). Myanmar's small-scale fishers operate in a general context of poverty, low education, ethnic diversity and strong dependence on fisheries (Schneider and Thiha 2014). Marine resources are a major contributor to food security, pro- viding direct livelihoods for an estimated 1.4 million fishers (DoF 2017), with per capita consumptions remaining one of the highest in the world (FAO 2012). Fishing is the main source of livelihood for those living in the Myeik Archipelago, and can be characterised as a multi-gear, multi-species fishery with limited access to outside markets (Schneider and Thiha 2014). Furthermore, these fishers are from di- verse ethnic backgrounds with varying historical association with the islands (Schneider and Thiha 2014). These diverse community characteristics represent a relevant case study to examine how the restriction of resource extraction would impact different individuals and in- form how MPAs can be designed to minimise detrimental livelihood impacts on the most vulnerable community members.

In the Myeik Archipelago, MPAs are mostly in the inception stage of design and development. For example, in the south of the Myeik Archipelago, Lampi Marine National Park (MNP) is an IUCN category II MPA that theoretically functions through a top-down governance system in which the state controls management through laws and other regulations, with the dual objective of protection of biodiversity and sustainable human development (MOECAF 2014). While the park boundaries have been allocated and a draft zoning plan has been designed, management inputs are still in the early stages, resulting in minimal biodiversity or livelihood implications from the MNP to date (Dearden 2016).

Data collection

Field work was carried out during November and December of 2017 and was a part of a broader socioeconomic study that focused on characterising small-scale fishers' livelihood behaviours, and small- scale shark fisheries in the Myeik Archipelago. Data were collected by Myeik University research staff, all of whom were trained to record socioeconomic and fisheries data. Interviews were conducted in Burmese language, or local Moken dialects through an additional translator. Prior to fieldwork, surveys were trialed in Myeik Township with mainland fishers to ensure interpretability of the survey and mapping exercises. Within the three communities, I lead a series of structured, face-to-face surveys with active, mobile fishers to obtain quantitative data on the four socioeconomic factors that re- presented vulnerability (Appendix 3). I targeted respondents through the intercept approach in locations that fishers gathered, and subsequently via snowball sampling. This sampling method was considered most appropriate to obtain a representative sample of fishers in the targeted communities, because it maximises interviews with hard-to-find individuals (Miller et al. 1997) such as semi-nomadic Moken fishers for whom no registry database was available. I also led a participatory mapping exercise with each fisher to identify the location of their three most frequented fishing grounds on a satellite image of the area. For these exercises, participants were also asked a series of questions concerning the spatio-temporal characteristics of their fishing grounds, their home village, and various other biophysical landmarks of the Myeik Archipelago to ensure their conceptualisation of the seascape and map were aligned. While a total of 120 participants were interviewed, I excluded incomplete datasets, leaving a total of 80 fishers contributing to this study (Lin Long n = 26; Don Pale n = 24; Makyone Gallet n = 31).

Analysis

Material Style of Life

Twenty-six binary (absent/present) variables pertaining to house- hold items (Material Style of Life, MSL) were obtained from each fisher. To ensure variability in the data I removed factors for which 80% of the participants' answers were alike. I then conducted a Pearson's correlation analysis and removed those factors correlated to over 0.8, leaving six variables: generator ownership, no access to electricity, boat ownership, roof material (metal), wall material (wood), wall material (thatch). As generators are only one type of electricity source (other sources include battery and solar), 'no access to electricity' implied that the individual had no access to any type of electricity whatsoever.

I conducted principal component analysis of a covariant matrix of the remaining six binary MSL variables using SPSS (v.25) (Pollnac and Crawford 2000). Kaiser-Meyer-Olkin's measure of sampling adequacy was 0.62, and Bartlett's test of sphericity was significant (χ^2 = 146.16, $p \leq .01$), indicating that the data were well suited for a principal component analysis (Field 2018). Factor loadings greater than 0.4 were retained for interpretation in accordance with Fornell and Larcker (1981). I retained the rescaled Component One because it accounted for 40% of the variance (Appendix 4). I interpreted this component to highlight where an individual fell on the wealth spectrum. Those with high MSL were characterised as being most wealthy: owned a generator, owned a boat, and had a house made from non-degrading materials. Those with a low MSL score were least wealthy because they were less likely to have access to electricity, own a boat or have a house made from non-degrading materials. Component scores for the 80 individual fishers were then used to represent wealth.

Livelihood Impact Potential

I generated a Livelihood Impact Potential Index (LIPI) score for each individual small-scale fisher based on data obtained for each of the four socioeconomic factors (Table 1). I adjusted the factor outputs so that they were consistent in directional influence on vulnerability (i.e. low vulnerability would entail high livelihood diversity, high education, low age and high MSL). Therefore, I reversed the results for age. I standardised each factor on a scale of 0–1, then summed the standardised scores, and divided the result by four to develop an LIPI score between 0 and 1. To test if the LIPI was sensitive to any one particular factor, I conducted a sensitivity analysis by varying the value of each factor by 10% and monitoring resulting changes in the LIPI (Hamylton 2017). A low LIPI score represented individuals facing the fewest challenges with regards to vulnerability in the face of MPA-associated livelihood restrictions. A high LIPI score represented individuals with the greatest challenges in adapting to MPA-associated livelihood restrictions.

Each fisher's annotated satellite image was scanned and georeferenced to digitise their most frequented fishing grounds. ESRI ArcGIS version 10.3 was used to attribute each fisher's LIPI score to their associated fishing grounds. Fishing ground polygons overlapped, so Union and Spatial Join tools were used to quantify the number of fishers who used each area (i.e. fishing pressure) and to calculate the average LIPI value of all fishers who operate in each area. This enabled me to identify the areas that would be most detrimental to fishers' livelihoods if they were restricted from use due to an MPA.

Results & discussion

In the following, I describe how the LIPI can be used to support MPA planners to create MPAs that limit negative impacts on the most vulnerable small-scale fishers, using an example from Lampi NMP.

Livelihood Impact Potential Index (LIPI)

The LIPI is a composite score based on four local-level socio- economic factors that describe the degree to which a small-scale fisher is vulnerable to MPA-related restrictions on their livelihoods. Across the 80 fishers in my sample, mean values for the socioeconomic factors were: age = 41.89 years (SD =

13.19); education = 3.37 years of formal schooling (SD = 0.34); livelihood diversity = 1.41 livelihood strategies (SD = 0.06); wealth = 0.41 MSL (SD = 0.02). Mean LIPI score was 0.35 (SD = 0.02) (Figure 8). My sensitivity analysis showed that the mean LIPI score for each of the factor value iterations remained within 10% of the combined LIPI score (Appendix 5). This suggests that LIPI is a robust measure and is not overly skewed by any particular factor. By attributing each fisher's LIPI score to their fishing ground(s) I was able to spatially identify areas that would be most detrimental to fishers if they were restricted from fishing there. Mean LIPI scores for overlapping fishing grounds were used to highlight areas where, on average, fishers would be least likely to adapt to MPA- related restrictions (Fig. 9).

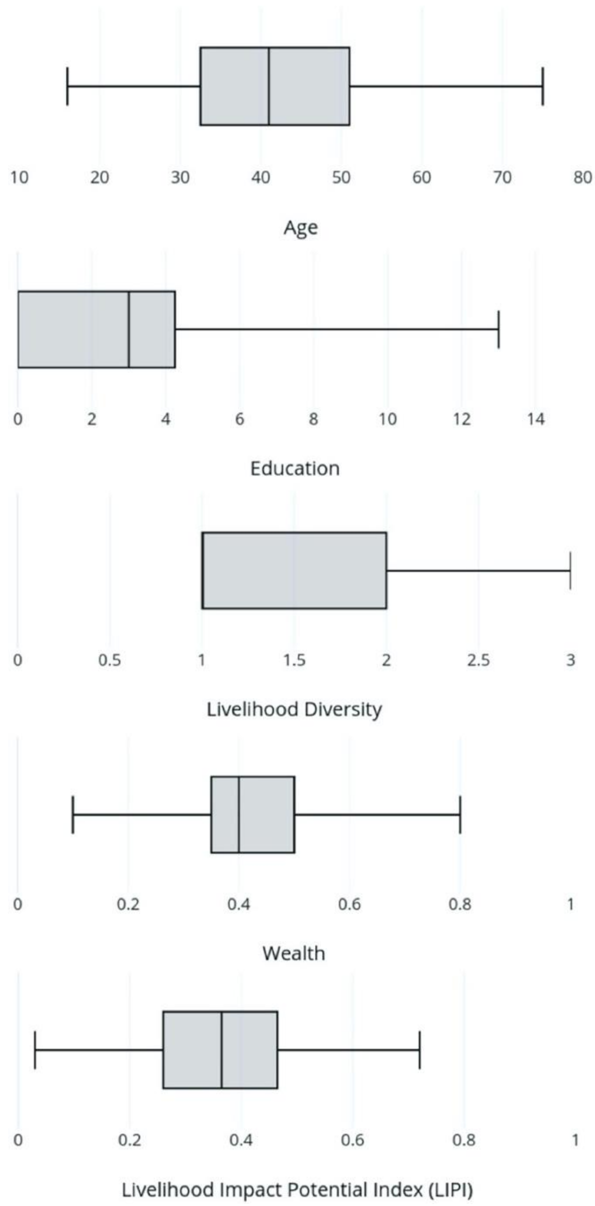

Figure 8. Spread of input socioeconomic factors (actual results) and Livelihood Impact Potential Index (LIPI) among small-scale fishers in the Myeik Archipelago.

Boxplot displays values for minimum, first quartile, median, third quartile, and maximum scores for each factor and the LIPI.

Vulnerability of fishers in the Myeik Archipelago

All of the fishers interviewed in this study used three or fewer livelihood strategies and had generally low education levels (Fig. 2), indicating a generally low propensity for livelihood diversification. While this result highlights characteristics typical of many small-scale fishing communities (e.g. Mohamed Shaffril et al. 2017), the other two socioeconomic attributes varied more among fishers. Those individuals with a low LIPI score were characterised as being slightly more educated and having slightly more diverse livelihood strategies. However, the important variation was that individuals with low LIPI scores were most wealthy and youngest. These attributes describe fishers with the greatest ability to adapt a livelihood strategy to cope with MPA-associated restrictions to their fishing grounds. While this does not imply that these fishers should not be supported or that their livelihood needs should be disregarded, research has shown that fishers are more likely to perceive benefits from MPAs when they are wealthier, regardless of whether they have one or multiple livelihood strategies (MacNeil and Cinner 2013). Furthermore, other, comparable studies have shown that more wealthy individuals in communities are more likely to be positioned such that they are influential in policy-related decision making processes and benefit from local government arrangements (Adger and Kelly 1999, Christie 2004). This positioning coupled with youth and education can signify that an individual will be less risk-averse in exploring new livelihood opportunities, and will be better equipped with the tools to adapt to restriction on fishing from the outset (Gurney et al. 2015). Conversely, those individuals who scored highly on the LIPI are likely to require the greatest support if their livelihood activities are restricted as a result of no-take MPAs. Less wealthy individuals are more likely to perceive a livelihood benefit from MPAs when they are involved actively in decision making (MacNeil and Cinner 2013), so effort should be made to engage with these individuals in the MPA planning process. Moreover, if their fishing activities are to be restricted, these individuals are likely to need more time to adapt to and understand the MPA process, and may require assistance in diversification of livelihoods, investments in education, and developing forums to maintain and foster ecological knowledge.

Operationalising LIPI

While the aforementioned results describe the varying socio- economic characteristics of small-scale fishers, it is useful from a marine spatial planning perspective to link these characteristics to the individuals' fishing grounds. By assigning fishers' LIPI scores to fishing grounds, I was able to discern the potential impact an MPA could have on individuals' livelihoods, depending on its location. When coupled with information on fishing concentration (i.e. number of fishers' who identify that area as one of their three most frequented sites), sites can be identified where MPAs are most likely to have bio-diversity benefits, and least likely to restrict fishing activities of highly vulnerable individuals. To illustrate, I highlight three areas within Lampi NMP that represent varying LIPI milieus (Fig. 4).

In area ‘A' the average fisher has a higher LIPI value, reflecting general high levels of vulnerability. If regulations within Lampi were to restrict access to this area, then the most vulnerable fishers will be most compromised. These fishers are likely to be pushed further into poverty traps (Cinner et al. 2012) or will simply not comply with restrictive legislation out of necessity (Ostrom 2007). In addition, fishing con- centration within this ground is low (i.e. less than four fishers identified this space as a fishing ground), meaning that benefits to biodiversity resulting from restricting access are likely to be minimal. Lampi NMP planners could choose to re-evaluate the importance of protecting this area or consider a zonation that supports these fishers by allocating specific fishing rights to high LIPI fishers. This would allow for both ecological and socioeconomic benefits, and potentially increase support for the NMP. In area ‘B' a low average LIPI score for fishers in this area implies most fishers will be relatively more capable of adjusting to no- take restrictions (Fig. 10a). However, given the low fishing concentration (Fig. 10b), biodiversity benefits might also be low, suggesting that it could be unnecessary to devote resources to protecting such an area. Rather, an optimal area to restrict access is one where average LIPI is low, and fishing concentration is high, which should in turn promote positive impacts for biodiversity while minimising negative impacts on more vulnerable small-scale fishers. In area ‘C’ the average LIPI is low, suggesting a general ability for fishers to adjust to restrictions, and fishing concentration is high, indicating substantial benefits to biodiversity if fishing activity were removed. NMP planners can identify communities where fishers within area ‘C’ that are on the lower end of the LIPI spectrum live (e.g. outliers or bottom quartile), and develop programmes to support them appropriately throughout the MPA implementation process (e.g. livelihood diversification, and investments in education). Since targeting individuals based on their LIPI scores could be a sensitive issue, MPA planners should remain sensitive to this, for example by having a voluntary programme for all fishers fishing in those zones so people can opt in or out rather than singling out individuals. In addition, LIPI scores are unlikely to remain static as associated measures such as wealth may change over time. As such, MPA planners should be mindful of this and attempt to re-evaluate the status of vulnerable fishers where possible.

Implications for MPA planners

Understanding how MPAs impact small-scale fishers is fundamental to ensuring that MPAs are designed to have equitable benefits, and to promote biodiversity benefits through increased likelihood of compliance with MPA legislation (Day 2017, Giakoumi et al. 2018). Public participation in the MPA planning process is increasingly legally required in many places, including Myanmar, and widely advocated in the academic and policy literature, not only as a means to minimise negative impacts on small-scale fishers, but also to build public trust and support for MPAs and decision makers (CBD 2010, FAO 2015, Day 2017, Giakoumi et al. 2018). While at times it might be unrealistic to identify the needs of every individual in every fishing community, it is vital to recognise that not all small-scale fishers will be equally impacted by MPAs, particularly in socially and economically heterogeneous locations such as the Myeik Archipelago. The LIPI offers a means for systematically identifying where resources to support vulnerable fishers could be allocated to benefit particular vulnerable fishers, with application alongside a stakeholder consultation process. Fig. 11 indicates where considerations related to the LIPI might be included the MPA planning process.

While the LIPI helps to identify highly vulnerable individuals, it is worth noting that actions to improve livelihood diversification have often failed in developing countries (Sievanen et al. 2005), with poverty and old age being critical obstacles (MacNeil and Cinner 2013). The combination of these attributes in high LIPI individuals suggests a group of people who will have particular problems in adapting to restrictions on their fishing grounds. Diversification might not be an option for these fishers if they are so profoundly trapped by poverty that trying an alternative livelihood strategy will be unrealistic without additional support or safeguarding. In addition, the promotion of alternative livelihoods is sometimes based on several assumptions, including that fishers are willing to forfeit fishing in favour of other livelihood opportunities, and that if they do so, pressure will be reduced on fisheries (Sievanen et al. 2005). Therefore, MPA practitioners might consider whether they should, in fact, place an MPA in an area where there is a general high LIPI context. If they must, planners might choose a less restrictive zonation strategy rather than 'no-take', that allocates specific fishing rights some fishers (e.g. local-use zone) or fishing practices (e.g. hang-line fishing) within these grounds, and restricts other users such as commercial fishers, or destructive fishing practices (e.g. long-line fishing) thereby releasing pressure on these areas while simultaneously gaining support for MPAs.

Finally, though the LIPI presents a fine-scale indicator of adaptive capacity of small-scale fishing communities, the index can be most beneficial when used alongside biological considerations such as location of threatened ecosystems, and information about commercial fisheries that operate in the same space. Furthermore, while the LIPI is a quantitative index based on objective factors that provides some context for equitable MPA planning, planners should not neglect to include other socioeconomic considerations (e.g. local context, and political and economic drivers) within the spatial MPA design process. It will be particularly important for planners to recognise and consider other, more subjective factors, that are not captured within the LIPI (e.g. wellbeing Seara et al. 2017). This holistic approach to understanding an area's socioeconomic and biophysical context will support MPA planners in making well-informed decisions about conservation, tailored to the unique context of each small-scale fishing community.

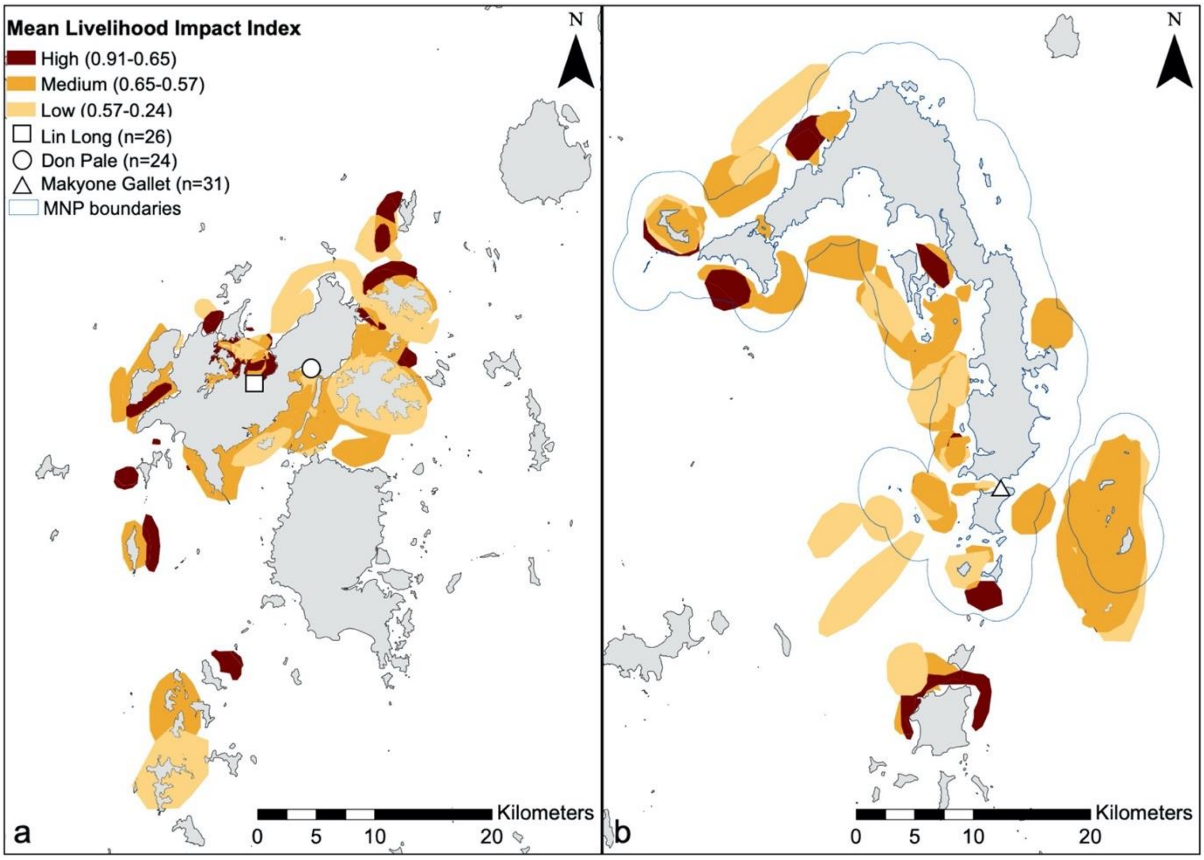

Figure 9. Mean Livelihood Impact Potential Index (LIPI) for identified fishing grounds in the Myeik Archipelago.

9a: Mean LIPI for small-scale fishers in Thayawthadangyi (Lin Long and Don Pale (total n = 50)); 9b: Mean LIPI for small-scale fishers in Lampi (Makyone Gallet (n = 31)).

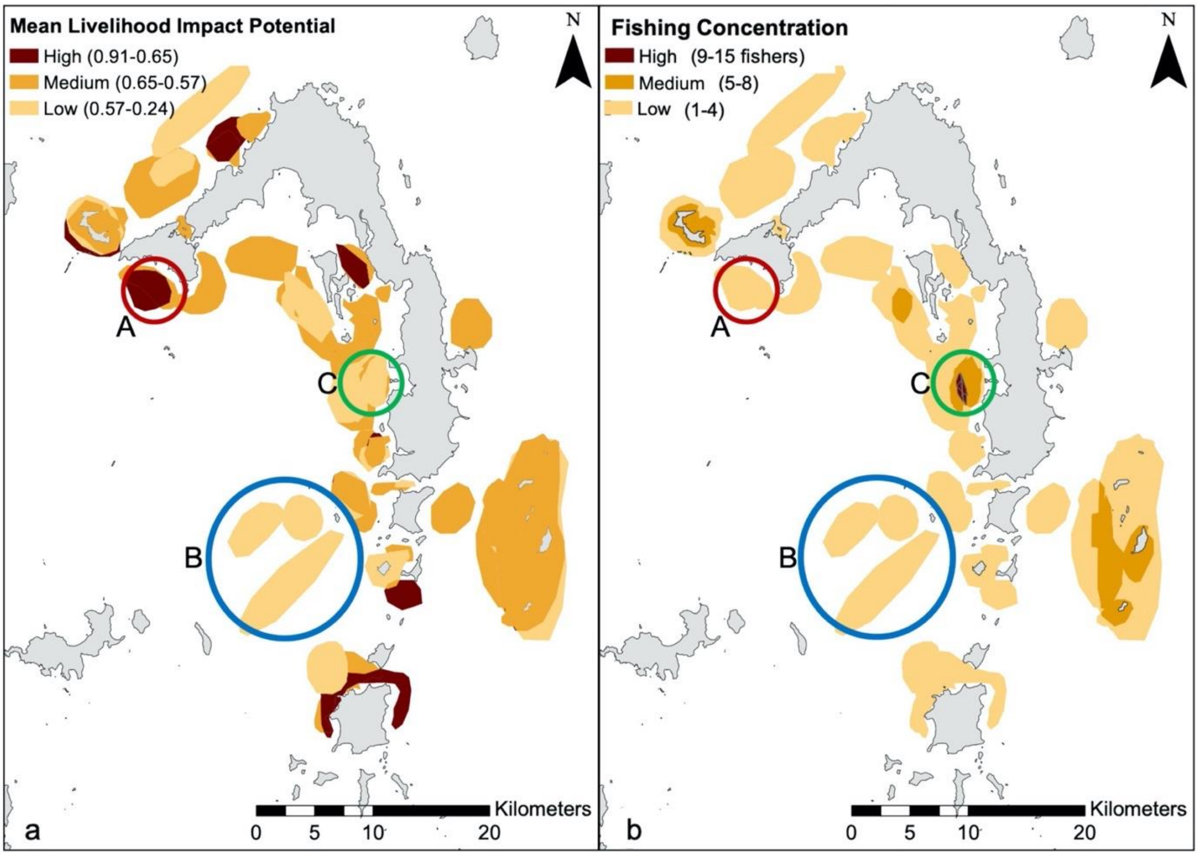

Figure 10. Mean LIPI values (a) compared to fishing concentration (b) of small-scale fishers from Makyone Gallet.

Area A highlights an area with high LIPI and low fishing concentration, suggesting that no-take MPAs located here would have limited biodiversity impact and would negatively impact many of the more vulnerable people in the community. Area B highlights an area with low LIPI and low fishing concentration, suggesting that most fishers will be relatively more capable of adapting to no-take MPA restrictions however, biodiversity benefits will be low due to low fishing concentration. Area C highlights low LIPI and high fishing concentration, suggesting that a no-take MPA placed here would maximise biodiversity impact while having livelihood impacts only on the least vulnerable people within the community.

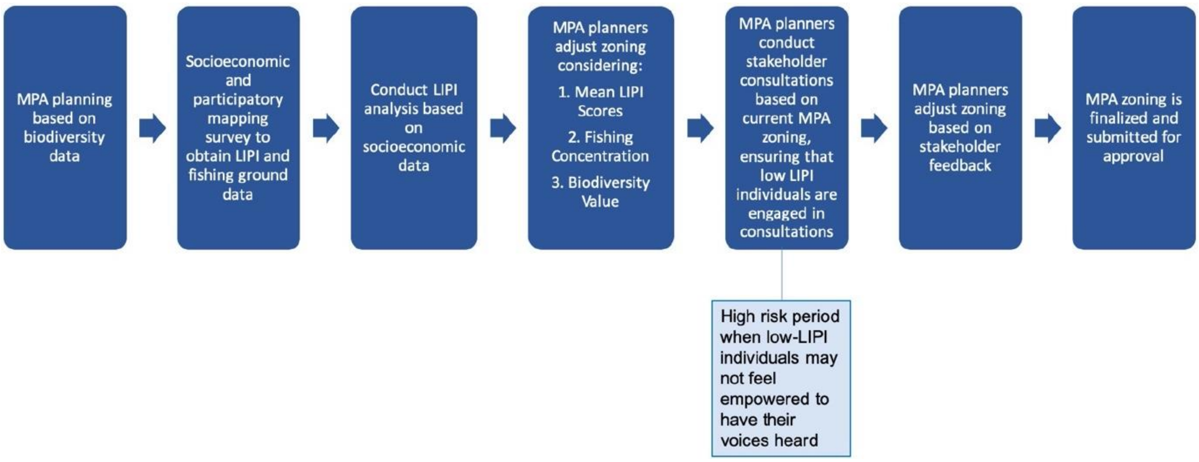

Figure 11. Flow diagram of decisions and for MPA planning using socioeconomic and biodiversity data, indicating where considerations related to the LIPI might be included.

Conclusion

Small-scale fishers across the globe are facing imminent threats and challenges to their livelihoods. While MPAs offer the potential to sup- port fisheries production, a failure to recognise the varying levels of vulnerability of many small-scale fishers means that well-meaning efforts to conserve resources can adversely impact the most vulnerable fishers in unintentional ways (Bennett and Dearden 2014). In this study, I developed a systematic and spatially explicit method to identify those individuals most vulnerable to being negatively impacted by no-take MPAs through an index that represents individual-level vulnerability to MPA restrictions. When used alongside ecological and commercial fishing data, the LIPI can support planners in designing local-scale MPAs that maximise positive impact on biodiversity, and minimise adverse impacts on the most vulnerable fishers in a community.

Chapter Five Summary

Chapter 5. Mitigating negative livelihood impacts of no-take MPAs on small-scale fishers

Abstract: Marine Protected Areas have the potential to support small-scale fishers in managing their resources. However, a general failure to consider the varying levels of vulnerability of fishers has resulted in MPAs that, often unintentionally, adversely impact small-scale fishers. Furthermore, when fishers lack the capacity to adapt to MPA-related changes, MPAs may fail to meet conservation objectives because fishers do not comply with MPA regulations. In this study, we developed a systematic method to identify individuals who are most vulnerable to being negatively impacted by no-take MPAs through an index that represents individual-level vulnerability. We designed a method for identifying these individuals based on four socioeconomic factors pertaining to vulnerability to MPA changes: livelihood diversity, education, age and wealth, then applied this method in two socially and economically heterogeneous communities in Myanmar's Myeik Archipelago. We used empirical data collected from 80 small-scale fishers in this area to represent each factor, then generated a local-level 'livelihood impact potential index' (LIPI) that reflects the degree to which a no-take MPA would impact an individual fisher's ability to support his or her livelihood. When attributed to each fisher's most frequented fishing ground, the LIPI can identify locations where no-take MPAs would be most detrimental to small-scale fishers' livelihoods based on their levels of vulnerability. The LIPI can thus be used alongside ecological and commercial fishing data to support planners in designing local-scale MPAs that maximise positive impact on biodiversity and minimise adverse impacts on the most vulnerable fishers in a community.

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Chapter Six. General Discussion

Chapter Six. General Discussion

Globally, MPAs are one of the most widely used approaches to conservation and marine spatial management (Lubchenco et al. 2003, Fox et al. 2012, UNEP-WCMC and IUCN 2019). MPAs are not, however, always placed in locations where they are most likely to maximise benefits to ecosystems and livelihoods (Devillers et al. 2015). Furthermore, current MPA guidelines fall short in that they focus primarily on biophysical criteria for benefits, with less consideration of interrelated socioeconomic factors. A contributing reason for this is the absence of an established, replicable, and broadly applicable set of socioeconomic factors to support decisions concerning conservation planning and MPA placement. Given that MPAs are increasing globally (UNEP-WCMC and IUCN 2019), there is a pressing need to better understand and incorporate socioeconomic factors into MPA planning.

The aim of my thesis was to identify the socioeconomic factors that influence effective placement of MPAs from an 'impact' perspective, and investigate the role that these factors play at national- and local-scales in influencing when, and if, MPAs are an appropriate approach to support marine ecosystems and associated livelihoods. To achieve this aim, I developed four research objectives that address key knowledge gaps pertaining to incorporating socioeconomic factors into MPA planning (Chapter One). Here, I provide a brief summary of the main findings and their interpretation from my data-based research chapters (Chapters Two - Five), discuss the implications of these findings for the advancement of theory and practice, and suggest areas for further research.

Achievement of thesis objectives and implications of findings

Chapter Two. A systematic review of the socioeconomic factors that influence how marine protected areas impact on ecosystems and livelihoods

Chapter objective: Identify the spatially explicit socioeconomic factors for effective placement of MPAs from an impact perspective.

The objective for this chapter was born from the absence of MPA guidelines that offer an interdisciplinary perspective to the spatial factors that promote maximum impacts of MPAs. I addressed this objective through a systematic review of the socioeconomic factors that influence whether MPAs have an impact on ecosystems and/or livelihoods. I used Pressey et al.'s (2015) definition of impact as the outcome relative to the counterfactual scenario of no protection. I identified 32 socioeconomic factors that fit this description and weighted the quality of evidence using an "Evidence for Impact" score (Figures 2 & 3). While identifying these factors is useful in its own right to guide MPA planning, two additional noteworthy findings emerged from this review.

Firstly, it was apparent that methods used for evaluating MPA impacts from a socioeconomic perspective are inconsistent, and rarely based on counterfactual scenarios. The studies in this review contained variable, often inconclusive, methods for evaluating MPA outcomes, making it difficult to establish causal relationships with impact. Furthermore, some studies that were highly cited, had little evidence for 'impact', suggesting that more research into those factors from an impact evaluation perspective is needed. Other studies had low numbers of citations but high evidence for impact, indicating that these factors may be being considered to a lesser extent in MPA planning. These factors (such as population age (Gurney et al. 2015), religion (Gurney et al. 2015) and wealth (McClanahan et al. 2006)) warrant greater consideration by researchers. This highlights a lack of consistent, robust methods for evaluating the influence of socioeconomic factors on MPA impacts, and the need for more empirical studies that include socioeconomic factors in their evaluation of MPA impact. This also suggests that given that impact is a relatively new concept in the protected area planning discipline (Pressey et al. 2015), there has been insufficient time for these evaluations to take place. Understanding which of these socioeconomic factors will lead to MPAs that have positive impacts is critical to the MPA planning process.

Secondly, some socioeconomic factors displayed 'bi-directional' impact on ecosystems and livelihoods, indicating that their influence is context-dependent. For example, MPAs with "strong leadership" could positively impact biodiversity (Crawford et al. 2006, Gutierrez et al. 2011), but not if leaders used their power and authority to obtain unequitable proportions of the benefits associated with marine resources (Sutton and Rudd 2015). This insinuates that for many socioeconomic factors, incorporating them into MPA planning is considerably more nuanced and challenging compared to biophysical factors, and that ascertaining national and local MPA context will be essential to incorporate socioeconomic factors into MPA planning effectively. For example, some factors such as the incorporation of existing taboos and land/sea tenure are more relevant at a local than national level and may vary from village to village. Other factors such as important fisheries can be interpreted differently depending on the location and scale of the MPA (e.g. small-scale vs. commercial). This highlights the importance for MPA planners to consider the context- and scale-dependent bidirectional nature that social dimensions of marine areas exhibit, when planning MPAs that aim to maximize conservation impact, and minimize undesired negative effects on resource users.

To the best of my knowledge, this research is the first major synthesis of peer-reviewed scientific literature that evaluates the spatially explicit socioeconomic factors that contribute to how MPAs impact on ecosystems and livelihoods. Impact evaluation is an important and emerging field of study for MPAs (Craigie et al. 2015, Devillers et al. 2015, Ferraro and Pressey 2015, Pressey et al. 2015, Chauvenet and Barnes 2016, Watson et al. 2016), as remarkably little is still known regarding the difference MPAs actually make to ecosystems and livelihoods. Nonetheless, impact evaluations have their practical limitations in that they are technically challenging (Baylis et al. 2016), and because they can often be costly and impractical to achieve in applied contexts (Craigie et al. 2015). Furthermore, conservation initiatives themselves are often expensive, and funds to support them are limited (Waldron et al. 2013). Given those expenses, expectations of a positive return on conservation investments can generate additional pressure for MPAs to appear successful (Bottrill et al. 2011), which de-incentivises the willingness to scrutinize failures, resulting in missed opportunities to learn from such failures. Nonetheless, when the impact *is* assessed, particularly from an interdisciplinary perspective, it can be a useful tool to yield knowledge on how to make MPAs function in a way that meets their conservation and livelihood objectives. My study supports that notion by providing a synthesis and interpretation of the socioeconomic factors that have been evaluated for MPA impact, and identifying areas that are in need of greater consideration from an impact evaluation perspective.

It is worth noting that the dearth in socioeconomics factors that have been evaluated from an impact perspective might be because in reality, MPA practitioners often use different types of socioeconomic evidence such as expert opinion, and knowledge gained from working in the field and with local communities (Scholz et al. 2004, Keppel et al. 2012, Keppel 2014). While it is not necessarily as academically rigorous from an impact perspective, this approach to MPA implementation allows conservation activities to be achievable because they establish community and local government buy-in. This highlights that impact evaluation alone will not be sufficient for including socioeconomic factors into MPA planning, and that scale, and context specific approaches that collaboration with communities and practitioners are key to developing MPAs that meet their conservations and livelihood objectives.

Chapter Three. Global opportunities and challenges for shark large marine protected areas

Chapter objectives: Highlight least developed and low-income countries where large-scale MPAs are more likely to be successful in providing conservation benefits.

The objective of this chapter was born from the need identified in Chapter One to consider the way socioeconomic factors are incorporated into MPA planning at varying spatial scales (i.e. national and local). At a national scale, I chose to demonstrate this through shark-specific EEZ-wide MPAs due to a recent trend for coastal nations to implement legislation that prohibits (to varying degrees) the capture and trade of shark products throughout their coastal territories (Ward-Paige and Worm, 2017). I addressed this objective by identifying and examining relevant national-level socioeconomic data, to determine the social and economic challenges and opportunities associated with implementing SLMPAs in 87 least developed and low-income countries. I used these data to identify nations where SLMPAs are more likely to be successful in providing conservation benefits to sharks while minimizing negative impacts on livelihoods. I used principal component analysis to develop two national-level indices that represent these anticipated opportunities and challenges for implementing SLMPAs from a socioeconomic perspective. These indices were solely obtained for low income and least developed countries as these are where trade-offs resulting from SLMPAs will be most apparent. High income and developed nations also have the greatest ability to implement effective management measures to achieve sustainable fishing (Simpfendorfer and Dulvy 2017), and thus have less need for SRMPAs.

This research produced two indices that can support policy makers in deciding when, and if SLMPAs should be implemented in a country. The 'Opportunity Index' identifies those nations in which socioeconomic conditions such as adaptive capacity, and equitable governance, are favourable for SLMPAs to support shark conservation. The 'Challenge Index' identifies those nations that may not yet be in a position developmentally to support communities to adapt to a loss of access to resources associated with SLMPAs, or to manage and enforce broad scale restrictive legislation.

Importantly, my research questions the appropriateness of large-scale MPAs in countries where significant social and economic issues are present. Restricting resource use in countries with limited adaptive capacity and high levels of institutional corruption is likely to result in MPAs that fail to meet their conservation objectives due to the absence of a social or economic safety net to support the loss of industry and livelihoods associated with restrictive legislation. Findings from this study complement the literature that affirms that conservation does not work in isolation from development (e.g. Gurney et al. 2015), and adds that in some cases, actions towards development should take precedence over conservation. This is not to say that socioeconomic and environmental interests are in conflict; in fact environmental challenges intersect with human actions, and therefore one cannot be considered without the other (Berkes 2007, T.N.C. 2018). However, in cases where socioeconomic contexts are such that national economies are largely dependent on fisheries, institutionally corrupt, or are economically vulnerable, SLMPAs may be more likely to fail due to lack of compliance, or the absence of political will to take MPAs from legislation into action (Crawford et al. 2006, Cinner et al. 2007, Broad and Sanchirico 2008, Guillaumont 2011, Gutierrez et al. 2011). For such cases, other social and economic concerns (such as improving education, diversifying economies and addressing institutional corruption), that are often divorced from conservation initiatives require greater consideration prior to MPA implementation.

While this chapter provides national-scale context for planning MPAs, the socioeconomic factors that form the Challenge and Opportunity Indices are not consistent throughout each nation, highlighting once again that local context is fundamentally important when designing local-scale MPAs. These national, higher level indices are useful as the data are available at a broad scale but provide minimal support to local level MPA planning. Diverse, context-specific approaches to MPA planning at a local level is therefore profoundly important to those nations that fall highly on the Challenge Index, in which SLMPAs are not deemed appropriate. Further understanding of these local level contexts are addressed in Chapters Four and Five.

Chapter Four. Small-scale fishers risk falling short amid economic and environmental reforms: a case study from Myanmar's Myeik Archipelago

Chapter objective: Explore how ethnic heterogeneity might influence fishers' vulnerability to experience negative outcomes from restrictions imposed by MPAs in small-scale fishing communities.

The objective of this chapter was born from results of Chapters Two and Three, that highlight the need to provide local-level socioeconomic context to small-scale marine fishing communities in order to support MPA planning. I addressed this objective by assessing a set of socioeconomic characteristics related to fishers' vulnerability to suffering negative outcomes from restrictions imposed by MPAs in three small-scale fishing communities in a case study site in Myanmar's Myeik Archipelago. This is a country that scored highly on the Challenge Index (Chapter Three), and therefore requires a deeper understanding of the local context before conservation management initiatives should be planned. To explore these dimensions, I used data from face-to-face interviews and participatory mapping exercises with 111 small-scale fishers. In this chapter, I used the data to characterise small-scale fishing in my study communities, and explore how variations among ethnic groups influenced their ability to adapt to changes (such as the establishment of an MPA) in the social-ecological system.

This study revealed a group of multi-species, multi-gear fishing communities, whose fishing practices were influenced largely by seasonal changes. Modernity of fishing technologies and socioeconomic characteristics such as education levels, livelihood diversity and cultural ties to fishing differed between ethnic groups. These attributes revealed that Moken fishers (an indigenous, ethnic minority group) were particularly vulnerable to MPAs imposing on their livelihoods and wellbeing, and also faced barriers such as language and cultural prejudice, which may limit dialogue with policy makers who determine strategies for natural resource management. Many indigenous people already consider protected areas to threaten their livelihoods (Dowie 2009, Stevens 2014) highlighting additional challenges in gaining community buy-in for MPAs in communities with indigenous resource users.

Results from this study support research such as Crawford et al. (2006) that highlights the unique challenges that ethnic heterogeneity presents to implementing traditional or community-driven MPAs (such as LMMAs). This research has significant and timely implications for MPA planning, given that the current global climate crisis is leading to an increase in rural-to-rural migration (Nations 2008, Cripps and Gardner 2016) and climate refugees (Farbotko and Lazrus 2012, Thomas Binet 2013, Clement et al. 2018). These large-scale human migrations resulting from the increased frequency of extreme weather events, resource scarcity, and other factors, particularly in the developing, tropical countries could result in ethnic heterogeneity increasing in otherwise ethnically homogenous communities. Examples of successful traditional management typically stem from areas where fishers hold land tenure, cultural ties to fishing grounds, historic linkages to fishing, and/or have strong community cohesion (Cinner et al. 2006, Weeks and Jupiter 2013). New migrants are likely to have less established relationships with marine areas, and different cultural values associated with marine resources (Foale and Dyer 2016). Challenges may thus arise when implementing traditional management if a previous reference point for fisheries has not yet been established. This also leaves indigenous or marginalized fishing groups increasingly vulnerable to experiencing both negative impacts of MPAs if their needs are not taken into consideration, and increased conflict over resources if these resources are not managed at all. These challenges are likely to have serious ramifications on individuals in many small-scale fishing communities, potentially including those that are currently considered ethnically homogenous. In my next chapter I suggest one method to consider the varying vulnerabilities of small-scale fishers in local-level MPA planning.

Chapter Five. Mitigating negative livelihood impacts of no-take MPAs on small-scale fishers

Chapter objective: Develop a systematic method to identify the optimal location for no-take MPAs so that they limit negative impacts on small-scale fishers with the highest levels of vulnerability to experiencing negative consequences from MPAs within a community.

This chapter emerged from the need to identify individuals who are most vulnerable to negative impacts of MPAs at a local scale. I addressed this objective by designing a spatially explicit, systematic method to identify the optimal location for no-take MPAs so that they limit negative impacts on the most vulnerable small-scale fishers within a community. Identifying these fishers is important, because when fishers lack the capacity to adapt to MPA-related changes, adverse impacts on fishers with high vulnerability can in turn lead to adverse consequences for biodiversity, whereby fishers fail to comply to MPA regulations unless strong enforcement is present (Ostrom 2007). Potential biodiversity gains from MPAs are therefore less likely in cases where policymakers fail to consider the local needs and vulnerabilities of resource users.

I designed a method for identifying particularly vulnerable individuals based on four socioeconomic factors pertaining to vulnerability (identified in the systematic review in Chapter Two) and applied this method in two of my three study communities in Myanmar's Myeik Archipelago. I used data collected from the small-scale fisher surveys and participatory mapping exercises to represent each factor, then generated a local-level 'livelihood impact potential' index (LIPI) that reflected the degree to which a no-take MPAs would potentially impact an individual fisher's ability to support his or her livelihood.
My research advances MPA planning by offering a novel means for systematically identifying where resources to support vulnerable fishers could be allocated to benefit acutely vulnerable fishers. Outputs from this research have important, practical implications for MPA practitioners working in developing local level MPAs, particularly in ethnically heterogenous communities as identified in Chapter Four. When this score is attributed to each fisher's most frequented fishing ground, the LIPI can help identify locations where MPAs would be most detrimental to small-scale fishers' livelihoods based on their level of vulnerability to suffering negative consequences from those restrictions. When used alongside ecological and commercial fishing data, the LIPI can support planners in designing local-scale MPAs

that maximise positive impact on biodiversity, and minimise adverse impacts on the least adaptive, most vulnerable fishers in a community.

This study builds on research that uses socioeconomic factors to inform MPA planning in the form of reducing conservation costs to individuals, rather than stakeholder groups as one homogenous unit (Brown and Corbera 2003, Daw et al. 2011, Fox et al. 2012, Milner-Gulland et al. 2014, Gurney et al. 2015, Kockel et al. 2020). Until recently, most studies have treated socioeconomic factors as costs and benefits, treating costs to stakeholder groups as an aggregate (Agrawal and Gibson 1999, Leach et al. 1999, Richardson et al. 2006, Waylen et al. 2013, Thiault et al. 2018). In these cases, minimising cost equates to minimising impacts of protected areas on stakeholders as one homogeneous group. However, this collective treatment of the negative impacts of MPAs on stakeholders disregards the potential for impacts to vary across stakeholder groups. Dependencies and values derived from marine ecosystems are likely to differ, either in magnitude or at a spatial scale, and with respect to social subgroups such as ethnicity (Crawford et al. 2006, Hicks and Cinner 2014). A failure to recognise ethnic heterogeneity could result in inequitable impacts of MPAs on livelihoods and wellbeing, which could result in conflict (Christie 2004), in turn reducing the likelihood of gaining stakeholders support MPAs, and thus compliance to MPA regulations (Ostrom 2007, Persha et al. 2011). Especially at a local scale, tools such as the LIPI can help to understand how MPAs might differentially impact individuals, a strategy that is critical to designing MPAs that promote equitable impacts among resource users.

Thesis limitations and opportunities for further research

Together, the chapters in this thesis contribute substantially to our understanding of how to incorporate socioeconomic dimensions into MPA planning from a national to local level. Outputs from this thesis contribute to the growing body of MPA literature that focuses on socioeconomic dimensions to MPA planning (such as Knight et al. 2006, Cowling 2007, Ban et al. 2009, Cinner et al. 2009, Mascia et al. 2010, Ban et al. 2013, Mills et al. 2014, Weeks et al. 2014). The spatial approach I used to incorporate socioeconomic factors into MPA planning paves the way for future research to continue in this area to further support MPA planners in designing MPAs with the greatest potential for positive impacts on ecosystems and livelihoods. In the following paragraphs I share some limitations of my research and suggest opportunities for further research.

My research in Chapter Two provides a major synthesis of peer-reviewed scientific studies that evaluate the socioeconomic factors that contribute to how MPAs impact on ecosystems and livelihoods. My results indicate that limited empirical studies exist that have taken an impact approach to evaluating how socioeconomic factors contribute to MPA success/outcomes. Impact evaluation is a relatively new approach that is complicated and costly to implement, and it is likely that a paucity of such studies would have influenced the results of my review. The presence of a larger body of research that uses an impact perspective would give a more accurate account of the relative relationship between socioeconomic factors and MPA outcomes. Gaining this perspective will require more researchers to conduct MPA research using impact methodology that tests against a counterfactual scenario. My work is a first attempt to synthesise this growing body of work, and concludes that before a final interdisciplinary set of guidelines for MPA placement can be produced, further research on socioeconomic impact evaluation needs to be incorporated.

The Challenge and Opportunity Indices (Chapter Three) represent current national-level socioeconomic contexts for 87 developing and low-income coastal nations. However national level socioeconomic factors that contribute to this research are regularly changing, and subject to dynamic global geopolitical systems, markets, and economic and environmental changes. Data used in these indices are often updated (e.g. the Economic Vulnerability Index), and revising data for Challenge and Opportunities indices to reflect changing social and political contexts will be necessary to keep these indices relevant. Furthermore, the indices were limited by the availability of global datasets at the national level, and therefore I could not incorporate every possible measure that would be relevant into the indices (e.g. a global dataset for small-scale fisheries was not available at the time of this analysis). An important opportunity to keep my research relevant is to monitor these changes, and update the indices accordingly. Another limitation is the exclusion of ecological and governance data in the spatial prioritisation of shark large MPAs (SLMPAs), which provided the national-level context for this chapter. For example, while the indices provide some valuable context for shark conservation interventions, they would be most beneficial when used alongside biophysical considerations such as location of threatened shark species (e.g. IUCN 2020), movement and migration patterns, (e.g. Lucifora et al. 2011) and governance and management measures (Davidson and Dulvy 2017). An opportunity also exists for these indices to be further refined so that they are applicable to regular LSMPAs (i.e. those without the specific objective of shark conservation). In this case, the indices could be used alongside other ecological data such as biodiversity hotspots (Briscoe et al. 2016), coral reefs (IMARS 2020, ReefBase 2020) or commercial fishing data (GFW 2016-2020).

Similarly, from a local perspective, integrating ecological data with the LIPI (Chapter Five) would lend further support to the design of MPA zoning that avoids restricting areas where highly vulnerable fishers fish, while targeting locally pertinent, ecologically significant marine sites to improve conservation impact. The inclusion of a biological assessment of important ecological areas (e.g. coral reefs, seagrass beds and mangroves) was beyond the scope of the study. By considering these additional factors, this more holistic, interdisciplinary approach to understanding an area's socioeconomic and biophysical context would better support MPA planners in making well-informed decisions about conservation, tailored to the unique context of each small-scale fishing community.

Finally, my research (Chapter Four) has shown that currently, a dearth of empirical studies that characterise Myanmar’s small-scale fishing communities reflects a situation whereby small-scale fishers in the Myeik Archipelago are potentially vulnerable to imminent environmental reforms

(Prescott et al. 2017, Tezzo et al. 2018, OOC 2019). This highlights an important opportunity to expand my research by continuing to investigate further into small-scale fishing communities in Myanmar's Myeik Archipelago as well as further afield. Myanmar is among the world's top 10 fish producing nations, producing over 3 million metric tons of fish in 2016 (FAO/FIGIS 2017). Despite being one of the most important fisheries globally, and the value fisheries hold on the country's economy and culture (Tezzo et al. 2018), they remain some of the least documented. Current information stems mostly from technical reports (e.g. Schneider and Thiha 2014, Howard et al. 2015), and to the best of my knowledge, my research is one of three peer-reviewed studies that examine fisheries in Myanmar (Belton et al. 2018, Tezzo et al. 2018), and the first to focus on Myanmar's small-scale marine fishers. Given that Myanmar is now emerging into a time of unprecedented economic and political transformation, there is urgent need for increased empirical research in this area.

Conclusion

MPAs are increasingly used as a measure to support marine conservation and resource management. Given the expansion of MPAs globally, better approaches to incorporating human dimensions into spatial prioritisation of MPA sites are critically important. My thesis contributes to the theory and practice of MPA planning by identifying the socioeconomic factors that can support MPA placement and demonstrating how these factors can be incorporated into MPA planning at multiple spatial scales. I met the objectives of my thesis by identifying the spatially explicit socioeconomic factors that can support MPA planning from an impact perspective, designing tools for incorporating these factors into decisions about MPA placement at national and local scales, and investigating how MPAs might impact vulnerable small-scale fishing communities in Myanmar. My results demonstrate the importance of broadening and systematising the way socioeconomic factors are incorporated spatially into MPA planning and evaluation, with contributions to both theory and practice. Stronger consideration of the social dimensions in MPA planning is critical to improving the likelihood that MPAs will benefit marine ecosystems, as well as the livelihoods that those ecosystems support.

Appendix

Appendix 1. Summary table for total number of socioeconomic factors (n=32), from journal articles published between 2006-2016, that were cited as evidence for impact or potential for impact on livelihoods and/or ecosystems.

Summary of significance for factors with both ≤ 1 citation and ≤ 2 Overall Evidence for Impact Score (OEIS) were excluded from this table due to small and/or weak evidence base for impact.

Socioeconomic Factor	General Summary of Significance for Livelihoods	References	General Summary of Significance for Ecosystems	References
Adaptive Capacity Livelihoods: OEIS (+)=1; OEIS (-)=NA n=2 Ecosystems: OEIS (+)=2; OEIS (-)=NA n=2	Societies with higher adaptive capacity can adapt most to MPA reducing fisheries livelihoods, thereby allowing them to be more accepted by the community.	(Cinner and Bodin 2010, Setiawan et al. 2012)	High adaptive capacity can result in strong support and compliance for MPAs, thereby allowing MPAs to maximise potential to make a difference. Poor adaptive capacity can result in closures that don't differ ecologically from fished areas.	(McClanahan et 2009, Voyer et 2015)
Dependence on Marine Resources Livelihoods: OEIS (+)=NA; OEIS (-)=2 n=2 Ecosystems: OEIS (+)=2; OEIS (-)=1 n=2	The people that are most reliant on marine fisheries are less likely to support MPAs, if they are perceived to reduce one's household income.	(Cinner et al. 2007, Broad and Sanchirico 2008)	'Bright spots' are located in areas of important fisheries; therefore MPAs have potential to make a difference here, given that communities comply with MPA regulations.	(Broad a Sanchirico 20(Cinner et al. 2016)
Distance to Fishing Settlement Livelihoods: OEIS (+)=NA; OEIS (-)=3	Fishers living adjacent MPAs have lower occupational diversity. Therefore MPAs may negatively impact fishers livelihoods the closer they live to MPAs, if they are not	(Cinner and Bodin 2010, Advani et al. 2015)	MPAs placed in areas close to fishing settlement can have impact on ecosystems, given that communities	(Advani et al. 20 Ahmadia et al. 201

Socioeconomic Factor	General Summary of Significance for Livelihoods	References	General Summary of Significance for Ecosystems	References
n=2 Ecosystems: OEIS (+)=4; OEIS (-)=NA n=2	supported through the process.		comply with MPA regulations.	
Distance to Market Livelihoods: OEIS (+)=3; OEIS (-)=NA n=2 Ecosystems: OEIS (+)=5; OEIS (-)=NA n=3	MPAs have potential to make a difference to fish catch when placed in areas close to market, as these are areas of lower biodiversity.	(Cinner and McClanahan 2006, Cinner et al. 2007)	Coral reef and reef fish biodiversity improves with greater distance to market. Therefore MPAs can have greater impact when placed in close proximity to a market, given that fishers comply with MPA regulations.	(McClanahan et 2006, Campbell et 2012, Cinner et 2013)
Economic Development Livelihoods: OEIS =NA n=0 Ecosystems: OEIS (+)=3; OEIS (-)=NA n=2	Small and/or weak evidence base for impact (both ≤1 journal article and ≤2 OEIS). Further evidence is required.	NA	Reef fish biomass decreases with proximity to greater economic development. Therefore MPAs can maximise impact in areas of intermediate to high economic development.	(Clausen and Yo 2008, Cinner et 2009)
Fishing Pressure Livelihoods: OEIS (+)=3; OEIS (-)=NA n=1	Small and/or weak evidence base for impact (both ≤1 journal article and ≤2 OEIS). Further evidence is required.	NA	Linking areas of high fishing pressure to reserves would decrease pressure on fisheries. In addition, overfishing of	(Lynch 20(Januchowski-Hartl et al. 2015)

Socioeconomic Factor	General Summary of Significance for Livelihoods	References	General Summary of Significance for Ecosystems	References
Ecosystems: OEIS (+)=4; OEIS (-)=NA n=2			reef-grazers, which could cause algal overgrowth of corals. Thus MPAs have potential to make a difference on fish biomass if placed in an area of high fishing pressure.	
Important Fisheries Livelihoods: OEIS (+)=4; OEIS (-)=5 n=6 Ecosystems: OEIS (+)=4; OEIS (-)=NA n=4	MPAs have potential to increase important fisheries abundance and the proportion of individuals of commercial size. However MPAs that are placed in areas of important fisheries can negatively impact people who rely on these resources as their main source of livelihoods, unless provided with alternative, sustainable livelihoods	(Coffman and Kim 2009, Bertocci et al. 2014, Kamat 2014, Fletcher et al. 2015, Howarth et al. 2015, Santos and Brannstrom 2015)	By understanding what fisheries are threatened early on, MPAs have potential to slow or cease decline of threatened fish in areas of important fisheries	(Coffman and K 2009, Burgess et 2013, Bertocci et 2014, Howarth et 2015)
Level of Education Livelihoods: OEIS (+)=1; OEIS (-)=NA n=2 Ecosystems: OEIS=NA n=0	Formally schooled fishermen are more likely to agree or strongly agree with the statement on the need for MPA establishment and the potential increase in future income due to the MPA.	(Launio et al. 2010, Thomassin et al. 2010)	Small and/or weak evidence base for impact (both ≤1 journal article and ≤2 OEIS). Further evidence is required.	NA
Modernisation Livelihoods: OEIS (+)=2; OEIS (-)=NA n=2	MPAs have potential to make a difference more quickly on livelihoods in communities with fewer communications facilities, fewer small businesses and lower	(Crawford et al. 2006, Cinner et al. 2007)	Small and/or weak evidence base for impact (≤1 journal article and ≤2 OEIS). Further evidence is required.	NA

Socioeconomic Factor	General Summary of Significance for Livelihoods	References	General Summary of Significance for Ecosystems	References
Ecosystems: OEIS (+)=2; OEIS (-)=NA n=1	composite business development index			
Population Age Livelihoods: OEIS (+)=4; OEIS (-)=NA n=1 Ecosystems: OEIS=NA n=NA	Placing an MPA in areas with young population demography, have potential to have positive impact due to greater potential to gain environmental knowledge.	(Gurney et al. 2015)	Small and/or weak evidence base for impact (both ≤1 journal article and ≤2 OEIS). Further evidence is required.	NA
Population Density Livelihoods: OEIS (+)=2; OEIS (-)=2 n=5 Ecosystems: OEIS (+)=5 ; OEIS (-)=3 n=12	Customary management can progress more quickly in smaller communities. Foale et al. (2011) suggests that people in low human population areas have not yet developed conservation ethic, therefore MPAs have potential to make a difference to alleviate the threat of future overuse in smaller populations.	(Cinner et al. 2006, Crawford et al. 2006, Cinner 2007, Foale et al. 2011, Harris et al. 2012)	MPAs placed in regions with high population density are more likely to positively impact ecosystems. The outlier was Bruno and Valdivia (2016) who suggested that Coral reef degradation is not correlated with human population density; local factors related to population densities have minimal impact on ecosystems as global drivers such as ocean warming mask their impacts.	(Crawford et 2006, McClanahan al. 2006, Clausen a York 2008, Cinner al. 2009, Pollnac al. 2010, Mora et 2011, Campbell et 2012, Harris et 2012, Cinner et 2013, Deudero et 2015, Bruno a Valdivia 2016)
Poverty	MPAs can act to reduce poverty during time of	(Tobey and Torell 2006, Andam et al.	Small and/or weak evidence base for impact (both ≤1	NA

Socioeconomic Factor	General Summary of Significance for Livelihoods	References	General Summary of Significance for Ecosystems	References
Livelihoods: OEIS (+)=5; OEIS (-)=NA n=4 Ecosystems: OEIS=NA n=NA	implementation, however reductions in poverty, do not always continue to accrue over time.	2010, Ferraro and Hanauer 2014, Gurney et al. 2014)	journal article and ≤2 OEIS). Further evidence is required.	
Recreational Use Livelihoods: OEIS (+)=4; OEIS (-)=NA n=7 Ecosystems: OEIS (+)=5; OEIS (-)=NA n=9	MPAs placed in regions with high tourism value are more likely to result with positive economic impacts on livelihoods.	(Broad and Sanchirico 2008, Chae et al. 2012, Cisneros-Montemayor et al. 2013, Cagua et al. 2014, Gill et al. 2015, Marengo et al. 2015, Gonson et al. 2016)	Support from communities to improve health of reefs and beaches have rollover results on the environment. Therefore MPAs have potential to make a difference in areas of importance for tourism and recreational use, if tourism is managed accordingly.	(Broad a Sanchirico 20(Needham 20: Poonian et al. 20: Lamb and Wil 2011, Font and Llo 2014, Bravo et 2015, Lyons et 2015, Travaille et 2015, Gonson et 2016)
Religion Livelihoods: OEIS (+)=4; OEIS (-)=NA n=1 Ecosystems: OEIS=NA n=0	Placing an MPA in an area of religious groups, have potential to have positive impact due to gained environmental knowledge.	(Gurney et al. 2015)	Small and/or weak evidence base for impact (both ≤1 journal article and ≤2 OEIS). Further evidence is required.	NA
Stakeholder Engagement Livelihoods:	MPAs that do not take into consideration local stakeholders are likely to have negative	(Broad and Sanchirico 2008, Granek et al. 2008, Klein et al. 2008, Dimech et al.	MPAs placed in areas with strong community engagement have higher rates of compliance and	(Broad a Sanchirico 20(Granek et al. 20(Gray et al. 20: Aburto-Oropeza al. 2011, Read et

Socioeconomic Factor	General Summary of Significance for Livelihoods	References	General Summary of Significance for Ecosystems	References
OEIS (+)=5; OEIS (-)=NA n=13 Ecosystems: OEIS (+)=3; OEIS (-)=NA n=11	affects on local livelihoods	2009, Guidetti and Claudet 2010, Aburto-Oropeza et al. 2011, Aldon et al. 2011, Setiawan et al. 2012, Abecasis et al. 2013, Albert et al. 2013, MacNeil and Cinner 2013, Bennett and Dearden 2014, Mangubhai et al. 2015)	community support, allowing for MPAs to have significant impact on ecosystems	2011, Setiawan et 2012, Bender et 2013, Young et 2013, Chaigneau a Daw 20 Mangubhai et 2015, Cinner et 2016)
Strong Leadership Livelihoods: OEIS (+)=2; OEIS (-)=2 n=3 Ecosystems: OEIS (+)=2; OEIS (-)=2 n=3	MPAs can maximise impact on sustainable fisheries when placed in areas with strong leadership. In addition strong leadership will allow impact to progress more quickly, allowing positive effects associated to be seen rapidly by communities. However, 'strong' local leadership can also be detrimental if 'leadership' involves using power to capture benefits.	(Crawford et al. 2006, Gutierrez et al. 2011, Sutton and Rudd 2015)	MPAs can make a difference more quickly when placed in areas with strong leadership, resulting in positive ecosystem impacts.	(Crawford et al. 2006, Gutierrez et al. 2011, Sutton and Rudd 2015)
Taboos & Land/Sea Tenure Livelihoods: OEIS (+)=3; OEIS (-)=1 n=7 Ecosystems: OEIS (+)=4; OEIS (-)=1 n=9	If traditional tenure systems are fundamental to local communities compared to national laws, then there is likely to be more compliance/support for the MPA.	(Cinner and McClanahan 2006, Aswani et al. 2007, Cinner 2007, Weeks et al. 2010, Feary et al. 2011, Foale et al. 2011, Mangubhai et al. 2015)	Traditional management regimes, in particular customary closures, allow for ecosystems to be maintained. The outlier for this group was Foale et al. (2011) who suggested that fishing taboos typically follow social cycles rather than fishing	(Cinner et al. 2006, Cinner and McClanahan 2006, McClanahan et al. 2006, Aswani et al. 2007, Clarke and Jupiter 2010, Weeks et al. 2010, Feary et al. 2011, Foale et al. 2011, Mangubhai et al. 2015, Cinner et al. 2016)

Socioeconomic Factor	General Summary of Significance for Livelihoods	References	General Summary of Significance for Ecosystems	References
			cycles. Therefore placing MPA in a taboo area that does not account for fishing cycles or biophysical factors will not make a difference or will displace fishing effort outside of taboo area	
Trust Livelihoods: OEIS (+)=1; OEIS (-)=NA n=2 Ecosystems: OEIS (+)=1; OEIS (-)=NA n=2	MPAs are placed in areas where trust in management institutions is high, are more likely to be supported by local populations.	(Setiawan et al. 2012, Wynveen and Sutton 2015)	Trust is important for compliance. Therefore MPAs placed in areas where trust in management institutions is high are more likely to have compliance.	(Wynveen and Sutton 2015, Turner et al. 2016)
Urbanisation Livelihoods: OEIS=NA n=0 Ecosystems: OEIS (+)=3; OEIS (-)=NA n=3	Small and/or weak evidence base for impact (both ≤1 journal article and ≤2 OEIS). Further evidence is required.	NA	Urbanisation can result in biodiversity loss, therefore MPAs can maximise impact on ecosystems in areas of high urbanisation.	(Clausen and York 2008, Teixeira-Neves et al. 2016, Tkachenko et al. 2016)
Visual Proximity Livelihoods: OEIS=NA	Small and/or weak evidence base for impact (both ≤1 journal article and ≤2 OEIS). Further evidence is required.	NA	Co-managed protected areas in visual proximity of a community experience significantly strong ecological	(McClanahan et al. 2006)

Socioeconomic Factor	**General Summary of Significance for Livelihoods**	**References**	**General Summary of Significance for Ecosystems**	**References**
n=0 Ecosystems: OEIS (+)=4; OEIS (-)=NA n=1			outcomes. Sites within visual proximity are most effective at conserving resources due to higher compliance.	
Wealth Livelihoods: OEIS (+)=1; OEIS (-)=NA n=1 Ecosystems: OEIS (+)=4; OEIS (-)=NA n=1	Small and/or weak evidence base for impact (both ≤1 journal article and ≤2 OEIS). Further evidence is required.	(McClanahan et al. 2006)	MPA sites are most effective at improving ecological variables are in areas of low wealth (fortnightly expenditure).	(McClanahan et al. 2006)
Artisanal Fishing; Benefits from Marine Fisheries; Distance to Child's Community; Distance to Urbanisation ; Education Level of Fishers; Fishing Ground Size; Household Income; Human Migration; Origin, Employment & Education; Population Size of Village; Social Development Index	Small and/or weak evidence base for impact (both ≤1 journal article and ≤2 OEIS). Further evidence is required.	NA	Small and/or weak evidence base for impact (both ≤1 journal article and ≤2 OEIS). Further evidence is required.	NA

Appendix 2. Challenge and Opportunity Indices for 87 low income countries and subsets of contributing socioeconomic data.

Numerical values are all positively correlated with socioeconomic factors and indices

EEZ	Economic Vulnerability	Dependence on Marine Resources	Education Levels	Tourism	Corruption	Challenge Index	Challenge Rank	Opportunity Index	Opportunity Rank
Algeria	13	0.15	0.66	6.83	-33	-0.67237	66	-1.01217	79
Angola	38	1.11	0.48	3.80	-19	1.00366	12	-0.95824	78
Argentina	24	0.27	0.81	10.25	-39	-0.9929	75	-0.23569	40
Bahamas	40	1.19	0.72	47.83	-65	-0.86415	31	2.28833	3
Bahrain	33	0.40	0.72	9.73	-36	-0.37187	51	-0.19808	39
Bangladesh	24	0.51	0.46	4.35	-28	0.43304	28	-1.16183	84
Barbados	26	0.14	0.77	40.60	-68	-1.57584	84	1.69884	7
Benin	33	0.96	0.41	5.66	-39	0.60937	24	-0.58802	55
Brazil	20	0.06	0.68	7.90	-37	-0.67563	67	-0.67676	65
Brunei Darussalam	31	0.18	0.72	8.96	-62	-1.0229	76	0.4	24
Cabo Verde	38	6.12	0.53	44.90	-55	0.43885	27	2.17145	4
Cambodia	38	1.14	0.46	32.40	-21	0.9065	14	0.11393	32

EEZ	Economic Vulnerability	Dependence on Marine Resources	Education Levels	Tourism	Corruption	Challenge Index	Challenge Rank	Opportunity Index	Opportunity Rank
Cameroon	20	0.42	0.49	7.17	-25	0.2497	35	-1.21321	85
Chile	26	1.23	0.78	10.44	-67	-1.36783	82	0.66993	18
China	20	0.29	0.63	11.03	-41	-0.57903	64	-0.47774	51
Colombia	23	0.03	0.63	5.80	-37	-0.4217	53	-0.73932	69
Comoros	66	11.00	0.47	9.72	-27	2.71253	2	1.30633	11
Congo	26	0.13	0.52	4.01	-21	0.3916	30	-1.28302	86
Costa Rica	29	0.07	0.68	12.87	-59	-0.91767	73	0.37595	25
Cuba	33	0.09	0.78	10.68	-47	-0.85947	71	0.17298	30
Cyprus	16	0.04	0.79	22.33	-57	-1.61284	85	0.43672	23
Democratic Republic of Congo	29	0.66	0.48	1.76	-21	0.6768	22	-1.29328	87
Dominica	39	5.57	0.62	37.65	-57	0.12658	39	2.03443	5
Dominican Republic	22	0.15	0.62	17.18	-29	-0.28081	48	-0.56134	53
Ecuador	28	0.60	0.67	5.42	-32	-0.2262	44	-0.6543	60

EEZ	Economic Vulnerability	Dependence on Marine Resources	Education Levels	Tourism	Corruption	Challenge Index	Challenge Rank	Opportunity Index	Opportunity Rank
Egypt	17	0.12	0.60	10.99	-32	-0.38474	52	-0.86097	74
El Salvador	29	0.06	0.58	10.11	-33	-0.0374	41	-0.58599	54
Gabon	29	0.82	0.62	2.90	-32	-0.0118	40	-0.75374	70
Gambia	70	8.80	0.36	20.10	-30	2.84371	1	1.51161	9
Georgia	31	0.19	0.79	31.01	-56	-1.2053	81	1.17327	12
Ghana	37	0.85	0.55	6.25	-40	0.23606	37	-0.27978	44
Grenada	44	0.67	0.73	23.35	-52	-0.46547	55	1.08258	14
Guatemala	24	0.09	0.51	8.03	-28	0.19978	38	-1.01625	80
Guinea	26	2.00	0.33	5.32	-27	1.06159	10	-1.11082	82
Guyana	50	2.26	0.57	6.99	-38	0.74372	20	0.22432	29
Haiti	33	0.53	0.43	9.75	-22	0.89287	16	-0.92719	76
Honduras	30	0.28	0.52	15.01	-29	0.29735	34	-0.54344	52
India	21	0.22	0.54	9.38	-40	-0.21079	43	-0.65639	62

EEZ	Economic Vulnerability	Dependence on Marine Resources	Education Levels	Tourism	Corruption	Challenge Index	Challenge Rank	Opportunity Index	Opportunity Rank
Indonesia	24	0.99	0.62	5.79	-37	-0.26565	46	-0.61993	57
Iran (Islamic Republic of)	20	0.20	0.70	7.31	-30	-0.55838	60	-0.82709	73
Iraq	44	0.01	0.50	8.43	-18	0.96857	13	-0.77688	71
Israel	19	0.00	0.87	5.98	-62	-1.83861	86	0.15911	31
Jamaica	31	0.35	0.68	32.88	-44	-0.56064	62	0.7846	17
Jordan	19	0.00	0.70	18.65	-48	-1.03603	78	0.03622	34
Kenya	29	0.09	0.52	9.66	-28	0.30034	33	-0.80844	72
Kuwait	25	0.01	0.61	5.98	-39	-0.35315	50	-0.65138	59
Lebanon	16	0.02	0.66	18.43	-28	-0.53264	58	-0.65495	61
Liberia	57	1.91	0.42	5.12	-31	1.53339	7	-0.062	36
Madagascar	34	2.75	0.49	16.57	-24	0.88312	17	-0.26019	43
Malaysia	19	1.29	0.70	13.38	-47	-0.86596	72	-0.06336	37
Maldives	47	11.31	0.56	76.64	-33	1.55968	6	3.62043	1

EEZ	Economic Vulnerability	Dependence on Marine Resources	Education Levels	Tourism	Corruption	Challenge Index	Challenge Rank	Opportunity Index	Opportunity Rank
Mauritius	23	0.47	0.73	23.75	-50	-1.02611	77	0.45796	22
Mexico	19	0.26	0.66	15.99	-29	-0.44544	54	-0.62527	58
Morocco	15	1.86	0.50	18.64	-40	-0.13043	42	-0.33383	47
Mozambique	38	1.62	0.37	8.79	-25	1.26752	9	-0.6979	67
Myanmar	32	1.89	0.41	6.65	-30	0.89847	15	-0.71997	68
Namibia	35	3.44	0.55	13.81	-51	0.24107	36	0.55706	19
Nicaragua	28	0.78	0.54	12.69	-26	0.31164	32	-0.66385	63
Nigeria	34	0.26	0.48	5.08	-27	0.63006	23	-0.90339	75
Oman	25	0.88	0.65	6.62	-44	-0.49435	56	-0.33635	48
Pakistan	22	0.47	0.40	7.37	-32	0.4632	26	-1.08496	81
Panama	25	0.19	0.69	14.47	-37	-0.5655	63	-0.25741	42
Papua New Guinea	32	1.65	0.42	1.84	-29	0.87188	18	-0.9526	77
Peru	24	1.76	0.67	9.77	-37	-0.33911	49	-0.30752	45

EEZ	Economic Vulnerability	Dependence on Marine Resources	Education Levels	Tourism	Corruption	Challenge Index	Challenge Rank	Opportunity Index	Opportunity Rank
Philippines	25	1.11	0.64	21.14	-34	-0.25016	45	-0.05766	35
Qatar	27	0.13	0.70	10.02	-63	-1.08347	79	0.35465	27
Saint Lucia	42	0.42	0.68	41.83	-55	-0.52024	57	1.72096	6
Saint Vincent	38	0.55	0.66	23.38	-58	-0.55885	61	0.98824	15
Sao Tome and Principe	37	8.30	0.51	24.34	-46	1.03167	11	1.36545	10
Saudi Arabia	14	0.05	0.77	9.39	-49	-1.3738	83	-0.32847	46
Senegal	32	11.81	0.36	10.38	-45	1.85008	5	0.87933	16
Seychelles	44	1.37	0.71	65.31	-60	-0.66259	65	2.91632	2
Sierra Leone	50	8.10	0.37	4.14	-30	2.20385	4	0.30649	28
Singapore	29	0.00	0.81	10.18	-84	-1.87637	87	1.12077	13
Solomon Islands	49	14.22	0.45	10.36	-39	2.42141	3	1.54109	8
South Africa	23	0.15	0.71	8.93	-43	-0.78386	70	-0.34237	49
Sri Lanka	24	0.61	0.75	11.63	-38	-0.75374	69	-0.23977	41

EEZ	Economic Vulnerability	Dependence on Marine Resources	Education Levels	Tourism	Corruption	Challenge Index	Challenge Rank	Opportunity Index	Opportunity Rank
Suriname	65	1.70	0.63	2.69	-41	0.83667	19	0.55276	20
Tanzania	28	0.65	0.44	9.04	-36	0.40864	29	-0.67372	64
Thailand	24	2.04	0.64	21.19	-37	-0.26659	47	0.09512	33
Togo	34	0.57	0.49	8.67	-32	0.49714	25	-0.58862	56
Trinidad and Tobago	32	0.14	0.72	7.73	-41	-0.53755	59	-0.19806	38
Tunisia	18	0.43	0.64	14.20	-42	-0.68643	68	-0.351	50
Turkey	11	0.12	0.67	11.61	-40	-0.93247	74	-0.68433	66
United Arab Emirates	29	0.10	0.69	7.74	-71	-1.16517	80	0.52359	21
Vanuatu	47	2.77	0.53	9.35	-43	0.7364	21	0.37562	26
Yemen	35	2.01	0.35	5.19	-16	1.48149	8	-1.15761	83

Appendix 3. Survey and participatory mapping exercise.

Interviewer: Date:

Location: Survey #:

Hello, my name is ___, student/teacher from ___. I am here today to find out how people in ___village interact with the ocean. We hope to learn more about your fishing activities. We also hope to learn about your thoughts about sharks.

The interview should take around 30 minutes to complete. Your answers are completely confidential – we will not tell anyone else your answers. The information you provide will be used to guide our research – we will not share the information with anyone. Your participation is voluntary and you can stop the interview at any time. Please tell us if you do not want to answer a question, or if you do not understand the question.
Are you happy to go ahead?

Before we start, I have a couple of questions:
1. Do you currently live in this village? Yes No
2. Is fishing one of your activities? Yes No

Only conduct the survey if the respondent answers **'Yes'** to both questions.

Introduction

I would like to start by asking you some questions to learn more about you and your household.

Age: [ ] Gender: [ ]

Q1: Where are you originally from? (Circle)

This village

Other village in Myeik Archipelago (Specify) [ ]

Mainland Myanmar (Specify) [ ]

Outside of Myanmar (Specify) [ ]

Q2: How long have you lived in this village?

___ all my life OR ________ years

Q3: Which ethnic group do you identify with? (Mark X)

Karen	Moken	Burmese	Other (Specify)

Q4: What grade were you in when you finished school? _____

Q5: Number of people in household?
Working adults ______ Non-working adults ______children_____

Q6: Now I'd like to learn about the activities that you and the members of your household engage in to bring food and money into your household. Let's start with your activities and then we'll talk about the other members of your household.

Q6.1: What activities do you do to bring food and money into your household?

Q6.2.: What activities do other members of your household do to bring food and money into the household?

	*Activity. Indicate * for respondent*	*Rank*
1		
2		
3		
4		
5		

Q6.3: Please rank the top three most important activities for your household. Start with the most important first.
Section 1: Fishing Characteristics

Now I'd like to ask you some questions to learn about your fishing activities. (Show map) This is a map of the area. Before we start, I just want to confirm that you can orient yourself on this map. This is the island we are on, and Myeik is in this direction (*Interviewer: point in the direction of Myeik relative to the map*).

Please point out the location of this village.
Please point out the location of the neighbouring village
Please point out the location of…

Q7.1: Now, can you please use this **black marker** to draw a shape around the boundaries of your 3 main fishing areas – the 3 areas where you go fishing the most. *(Interviewer labels each shape by writing a letter next to it: A, B, C).*

Q7.2: Which of these 3 areas do you fish at the most? *(Interviewer marks an X on the map)*

Q8: Now I'd like to ask some questions about each of these 3 fishing areas. (*Interviewer: start with the area marked 'A', then move on to 'B', then 'C'*).

Site	Question							
	What is the main reason you fish here?	What months of the year do you fish here?	During these months, how often do you go fishing here?	How long does it take you to get here?	What gears do you use when you go fishing here?	What do you catch here? (*use fish ID guide)*		*(If identified to species):* Are most of these larger or smaller than the minimum length at maturity? (*refer to shark ID guide)*
						Photo number	**Local Name**	

(Interviewer: determine which column/question to refer to next, based on whether the respondent)…..

Has only reported catching **sharks**	Has only reported catching **rays**	Has reported catching **both sharks and rays**	**Hasn't reported catching sharks or rays**
Q9: Do you ever catch rays when you go fishing?	**Q9: Do you ever catch sharks when you go fishing?**	*Go to **Q11***	**Q9: Do you ever catch sharks or rays when you go fishing?**
Yes (*Go to **Q11***)	Yes (*Go to **Q11***)		Yes (*Go to **Q11***)
No (*Go to **Q12)***	No (*Go to **Q12)***		No (*Go to **Q12)***

Q11: You mentioned that you have caught sharks and/or rays while fishing. I would like to learn more about the sharks and/or rays that you catch. I am interested in what you catch on purpose, and also what you may catch by accident.

Site	Question						
	What sharks/rays have you caught here? *(use shark/ray ID guide)*		Are these caught on purpose or by accident? (I/A)	How many of this type have you caught at this site in the past year?	What do you do with it once you've caught it? (release/sell/eat)	*If respondent says they release them:* Why do you release them?	*If the respondent said they sell them:* Where are the buyers located?
	Photo number	Local name					

How much of your yearly household income comes from selling shark/ray products?
None / Less than half / about half / more than half / all

Can you get more or less money for shark products compared to 5 years ago?
Less / same / more /don't know

Q12.1: Do you ever see other people catching sharks or rays? *(Circle)*

No Only Sharks Only rays Both

*If 'No': Skip to **Q13**.*

If they respond 'Only Sharks', 'Only rays', or ' Both':
Q12.2: Can you please use this <u>red marker</u> to draw a shape around the main areas where you see other boats catching sharks or rays? *(Interviewer writes letter a, b, c inside for further annotation)*

Site	What months of the year do you see boats catching sharks/rays?	What is the level of targeted shark fishing at this site? (*low/medium/high)*	Where are these fishers from?	Do you know what types of sharks/rays are caught? *(Refer to shark/ray guide)*		Are these caught on purpose or by accident?
				Photo number	Local name	
		Low ____				
		Medium ____				
		High ____				
		Low ____				
		Medium ____				
		High ____				
		Low ____				
		Medium ____				
		High ____				
		Low ____				
		Medium ____				
		High ____				
		Low ____				
		Medium ____				
		High ____				

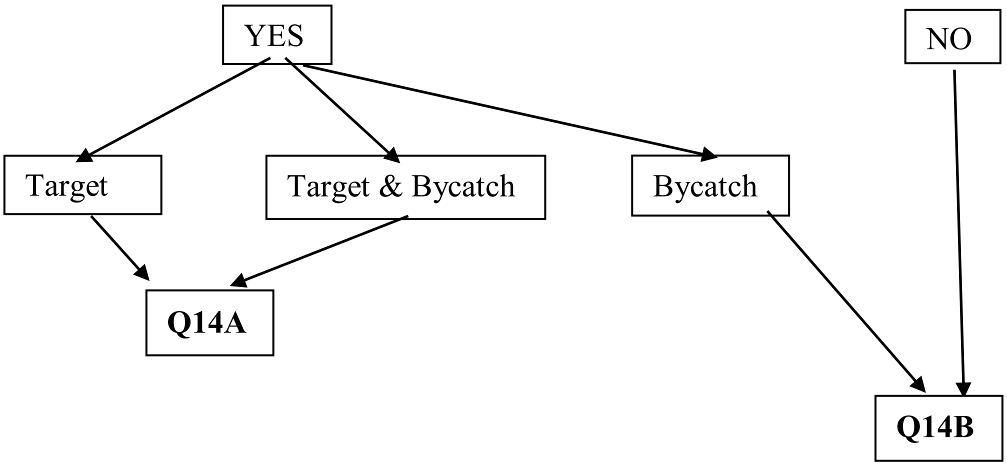
Q13: Are there any other areas we haven't talked about yet, where sharks and rays are known to occur? These areas may be either inside of your main fishing areas. Can you please use this <u>blue marker</u> to draw a shape around these areas. ***(Interviewer annotates with numbers – 1,2,3 etc.)***

(Interviewer: If the respondent does not know of any other areas where sharks and or rays occur, skip to Question 16)

Site	**Are there sharks or rays found here, or both?** Sharks / rays / both	**Do you know what species?**	
		Photo number	**Local name**

As I mentioned at the beginning of this interview, we are interested in learning more about your thoughts about sharks. So, for the rest of the interview I will be focusing on sharks.

*Interviewer: Has the respondent ever caught **sharks**?*



Q14A: For those who have targeted sharks	
Question	Response
Why do you target sharks? List up to two reasons.	1. 2.
How do you think other fishers in your village feel about you targeting sharks? Why do they feel this way?	Approve / disapprove / don't care / I don't know
How would you feel about other fishers in your village targeting sharks? Why would you feel this way?	approve / disapprove / wouldn't care / I don't know

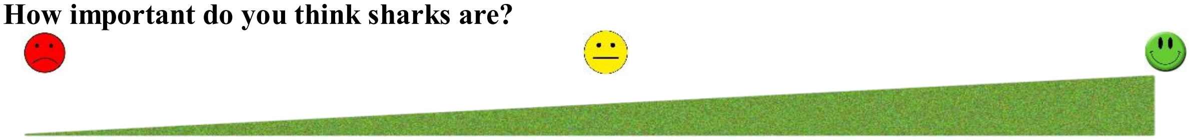
Q14B: For those who have <u>NOT</u> targeted sharks	
Question	Response
Why don't you target sharks? List up to two reasons.	1. 2.
How do you think other fishers in your village would feel about you targeting sharks? Why would they feel this way?	They would approve / they would disapprove / they wouldn't care / I don't know
How would you feel about other fishers in your village targeting sharks? Why would you feel this way?	I would approve / I would disapprove / I wouldn't care / I don't know

Section 2: Sharks and perceptions of the environment
Now I'd like to learn more about your thoughts on sharks.

Q15.1: In your opinion, are there more or less sharks than there were 5 years ago?
a lot more / a few more / same / a few less / a lot less / don't know

Q15.2: Why do you think this is?

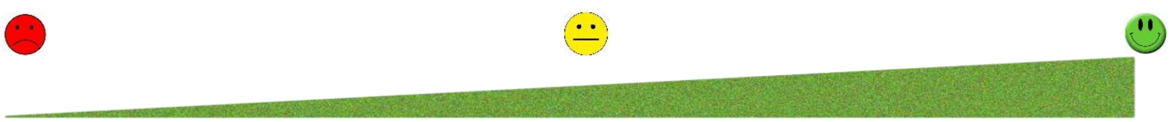
Q16.1: How important do you think sharks are?



0 1 2 3 4 5 6 7 8 9 10
Extremely unimportant *Extremely important*

Q16.2: Why?

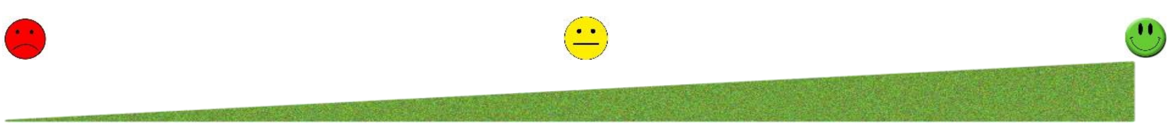
Q17.1: How important do others in your village think sharks are?



0 1 2 3 4 5 6 7 8 9 10
Extremely unimportant *Extremely important*

Q17.2: Why?

Q18: How much of an effect do you think shark fishing has on shark populations?



0 1 2 3 4 5 6 7 8 9 10
Very weak effect *Very strong effect*

Section 3: Perceived Compliance

Q19: In your opinion, what is the level of targeted shark fishing by people *in this village*?
There is no shark fishing / very low / low / medium / high / very high

Q20: In your opinion, what is the level of targeted shark fishing *in the Myeik Archipelago*?
There is no shark fishing / very low / low / medium / high / very high

Q21: In your opinion, what are the two biggest reasons why people in the Myeik Archipelago would target sharks? List the most important reason first.
1.

2.

Q22: In your opinion, what are the two biggest reasons why people in the Myeik Archipelago would NOT target sharks? List the most important reason first.

1.

2.

Q23: Do you think that sharks are in need of greater protection from fishing? Yes No

Q23.2: Why/why not?

Section 4: Legislation and Compliance

Q24: Are you aware of any rules or laws regarding fishing for sharks?

Yes No

STOP:
If the respondent has replied 'No', ***skip to Section 5****.*

Q25: What rules or laws are you aware of regarding fishing for sharks?

Rule/law 1.________________________
Rule/law 2.________________________
Rule/law 3.________________________

		Rule/law		
		1	2	3
Q26	How did you learn about the rule/law?			
Q27	Who is responsible for enforcing the rule/law?			

(Interviewer: reassure the respondent that we are getting close to the end of the survey)
Q28: For the rule(s) you mentioned, please tell us how much you agree or disagree with the following statements.
(If they have listed more than one rule): **I'm going to start with the first rule you mentioned: (*rule/law 1 from above)***

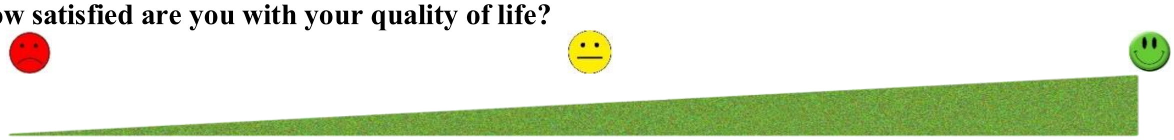
Question	Rule/law		
	1.	2.	3.
People are well informed about the rule	**0 1 2 3 4 5 6 7 8 9 10** **strongly strongly disagree agree**	**0 1 2 3 4 5 6 7 8 9 10** **strongly strongly disagree agree**	**0 1 2 3 4 5 6 7 8 9 10** **strongly strongly disagree agree**
Who should be responsible for sharing information about this rule?			
I support the rule *Why do you feel this way*?	**0 1 2 3 4 5 6 7 8 9 10** **strongly strongly disagree agree**	**0 1 2 3 4 5 6 7 8 9 10** **strongly strongly disagree agree**	**0 1 2 3 4 5 6 7 8 9 10** **strongly strongly disagree agree**
The rule has been effective for protecting sharks	**0 1 2 3 4 5 6 7 8 9 10** **strongly strongly disagree agree**	**0 1 2 3 4 5 6 7 8 9 10** **strongly strongly disagree agree**	**0 1 2 3 4 5 6 7 8 9 10** **strongly strongly disagree agree**
I was involved in the decision-making process that led to the rule	**0 1 2 3 4 5 6 7 8 9 10** **strongly strongly disagree agree**	**10 1 2 3 4 5 6 7 8 9 10** **strongly strongly disagree agree**	**10 1 2 3 4 5 6 7 8 9 10** **strongly strongly disagree agree**
Enforcement of the rule in my area needs to be improved *If response is above 5*: How could it be improved?	**0 1 2 3 4 5 6 7 8 9 10** **strongly strongly disagree agree**	**0 1 2 3 4 5 6 7 8 9 10** **strongly strongly disagree agree**	**0 1 2 3 4 5 6 7 8 9 10** **strongly strongly disagree agree**
I trust that the people enforcing the rules will do	**0 1 2 3 4 5 6 7 8 9 10**	**0 1 2 3 4 5 6 7 8 9 10**	**0 1 2 3 4 5 6 7 8 9 10**

their job effectively	**strongly strongly disagree agree**	**strongly strongly disagree agree**	**strongly strongly disagree agree**

Section 5: Satisfaction with fishing

Now I have some questions about your overall quality of life.

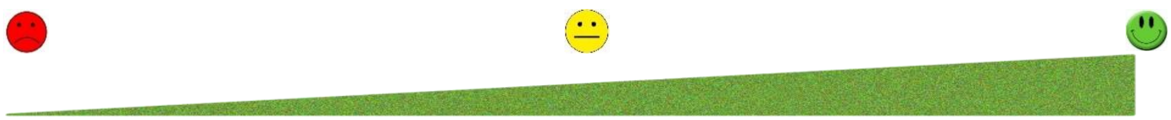
Q29: How satisfied are you with your quality of life?



0 1 2 3 4 5 6 7 8 9 10

Very dissatisfied *Very satisfied*

Q30.1: How satisfied are you with having fishing as one of your activities?



0 1 2 3 4 5 6 7 8 9 10

Very dissatisfied *Very satisfied*

Q30.2: Why do you feel this way?

Q31.1: Would you still be a fisherman if you had your life to live over? Yes No

If 'No':

Q31.3 Is there anything that you would prefer to be doing?

Section 6: To be completed with participant or through viewer observation

Q32: Please circle the relevant box.

Electricity

I own my own generator	I share a generator with another household	I do not have access to any electricity

Roof material

Thatch	Metal	Tile	Other (Specify)

Floor material

Dirt/soil	Bamboo/palm	Plank Wood	Cement	Finished (tiles, etc.)

Wall material

Bamboo/ thatch	Wood (plank)	Stone block	metal	Cement	Other

Transport

Boat Y / N *If Y:* With motor? Y / N	Other vehicle: Please list: _______ Type:

Q33: Finally, if we come back in the future, would you mind if we asked you more questions related to this project?

Yes No

(Interviewer: If yes, ask for name, contact details (address, mobile) and cross - reference with survey number in notebook)

Name:

Contact details:

Thanks for participating!!

END

Appendix 4. Survey and participatory mapping exercise.

Highlighted in bold are the factor loadings greater than 0.4 were retained for interpretation in accordance with Fornell and Larcker (1981).

	Rescaled Component 1	Rescaled Component 2
Generator ownership	**.900**	
No electricity	**-.881**	
Roof material (metal)	**.592**	.533
Boat ownership	**.425**	
Wall material (wood)		.901
Wall material (thatch)		-.867

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

Appendix 5. Sensitivity analysis for socioeconomic factors that contribute to the Livelihood Impact Potential Index.

Factor combination	**Number**	**Combined mean**	**Standard Deviation**
Combined score (all factors)	**80**	**0.36**	**0.15**
LIPI with 10% increase in age	80	0.38	0.15
LIPI with 10% increase in education	80	0.37	0.15
LIPI with 10% increase in MSL	80	0.37	0.15
LIPI with 10% increase in dependence on marine resources	80	0.37	0.15

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