HIDDEN DEPTHS:

HUMAN COSTS OF ENFORCEMENT & COMPLIANCE IN NO-TAKE MARINE PROTECTED AREAS

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ABSTRACT

Enforcement and compliance have been identified as key to the ecological effectiveness of no-take Marine Protected Areas (NTMPAs), which prohibit resource extraction in the marine realm. However, the human costs of abiding by NTMPAs have received little attention in comparison to the ecological benefits. As coverage of NTMPAs continues to rise worldwide, understanding human costs is important to the successful establishment and management of social relations around MPAs. Using key informant interviews and an online survey, this study identifies 18 human costs of compliance and enforcement and analyses their prevalence in time and space, as well as providing some suggested approaches to mitigating these costs. Results reveal transparency and communication in the establishment and management of NTMPAs, including engagement and education of local communities and training of enforcement officers, are key to mitigating the human costs of compliance and enforcement felt by enforcers and illegal and legal resource users.

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KEY TERMS

- Protected area (PA): Area that spatially restricts access to people for purposes of conservation or sustainable resource use
- Marine protected area (MPA): A PA in the marine realm
- No-take MPA (NTMPA): A type or portion of an MPA in which no extraction of resources is permitted
- Compliance: Choices made to adhere to regulations
- Enforcement: Actions taken to foster compliance
- Human costs: A variety of potential negative impacts on personal and professional life, including direct and indirect (opportunity) costs, which may be physical, material, psychological or social

INTRODUCTION

Over the last hundred years, severe recorded declines in marine biodiversity and ecosystem function have threatened not only the ocean but human livelihoods, as about 30% of fisheries are currently overfished and an estimated 12% of the world's population depend on fisheries and aquaculture for their livelihoods (Worm et al 2009, FAO 2016). Marine protected areas (MPAs) have gained popularity as a solution in the modern marine conservation movement, and currently exceed 12,000 in number and cover just over 3.4% of the world's oceans (Juffe-Bignoli et al 2014). However, only between 10% and 30% of MPAs are regulated and managed to successfully reach their objectives, and many more have been termed "paper parks," indistinguishable from surrounding areas (Mora et al 2006, Kelleher et al 1995, De Santo et al 2013). A review of MPAs worldwide carried out by Edgar et al (2014) identified no-take protection and strong enforcement as two key variables for MPA effectiveness. No-take Marine protected areas (NTMPAs), which prohibit the extraction of resources within spatially designated boundaries, make up around 13% of all MPAs (Wood et al 2008). The biodiversity benefits of NTMPAs are well established, with Lester et al (2009) finding that no-take protection resulted in average increases of 28% in organism size, 166% in organism density, 466% in biomass, and 21% in species richness within NTMPA boundaries. However, role of NTMPAs in aiding fisheries through spillover of marine organisms is less well determined, and the social costs of prohibiting fishing can be very high, negatively affecting local people's livelihoods and social dynamics even as they are promised benefits from improved sustainability of fish stocks in the long run (Roberts 2009, Cinner et al 2014).

While conservation has the potential to create long-term material, psychological and social benefits through increased sustainability, its implementation can also result in a variety of human costs (Balmford et al 2003). Ultimately, the effectiveness of NTMPAs will depend on humans adhering to the regulations that define them, but the social dimensions of compliance and enforcement remain little understood (Mascia 2004). Though research on the human costs of militarisation in terrestrial protected areas has begun to cast light on the social consequences of enforcement in conservation,

enforcement in the marine environment has received less attention (Duffy 2014, Norton 2015). Akella et al (2004) suggest that social pressure and fear of physical harm in clashes with illegal resource users can impact the effectiveness of enforcement. Marine examples of such costs can readily be found in the media, including violent protests in the Galapagos and the death of rangers in Palau (Schrope 2000, Urbina 2016). As "hard" methods of enforcement such as armed boat patrols can carry high social and financial costs, there is significant interest in increasing the efficiency of enforcement and encouraging voluntary compliance through methods of "soft" enforcement such as community outreach and education (López-Ornat et al 2014). Therefore, a greater understanding of the human costs of enforcement and compliance in NTMPAs is key to realising their potential social and ecological benefits.

In this study, I aim to identify and create a typology of human costs involved in global NTMPA enforcement and compliance through key informant interviews with experts on NTMPAs, including MPA managers, former rangers, fishers, and academics. I also conduct an online survey of the wider NTMPA community to gain a quantitative sense of how widespread these costs are and the groups they affect. I hope this typology of human costs and the potential solutions associated with them can be used to frame discussions in NTMPA establishment and management, and drawn on to identify the presence and severity of these costs in specific NTMPAs.

Human costs of enforcement and compliance in NTMPAs are a promising area of research, as complex social networks have been identified as key to the social and biological effectiveness of NTMPAs and PAs in general. As Brockington et al (2006) writes, "the ultimate challenge facing conservationists today is not only to reconcile errors of the past but also to determine how to shape human interactions with nature in landscapes of which people are a part" (p. 251). This project follows up on various calls for further investigation, including Bergseth et al (2015)'s claim "researchers should explore ways to better understand and measure non-compliance" (p. 240).

LITERATURE REVIEW

(Word count: 6,138)

Protected areas & human costs

For the last hundred years, protected areas (PAs) have been a dominant tool in terrestrial and marine conservation, aiming to preserve biodiversity and restrict human access to natural resources and landscapes based on spatial boundaries (Miller et al 2011, Stern 2008). The use of PAs is increasingly widespread and historically complex. At its root, the concept of a "protected" area has relied on a separation of nature and humans, which tends to place humans in one of two general roles: polluter or protector of nature, and enact spatial restrictions based on these categories (Cronon 1996, West et al 2006). This separation is closely linked to the birth of the conservation movement in the late nineteenth century, and is encapsulated in two influential values: first, the spiritual and emotional appeal of "wilderness" – or the wonder and value in pristine places, untouched by humans – which was popularised by the Romantic movement and strongly impacts conservation practice (Cronon 1996, Sloan 2002). The second key value is the notion that the human conquest of nature carries a moral responsibility to ensure the perpetuation of other life forms, which is fundamental to the practice of conservation (Hornaday 1914, Jepson & Canney 2003). However, the notion of human culture and nature as fundamentally separate has been challenged by social scientists and anthropologists, who have questioned the processes by which certain social groups are assigned power in conservation (West et al 2006).

The definition most often used for PAs is that provided by the International Union for Conservation of Nature (ICUN), which categorises and inventories PAs worldwide. This definition was updated in 2008 to apply to both marine and terrestrial PAs: "A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley 2008, p. 8). An alternative definition, supplied by Mascia (2004) for no-take Marine Protected Areas (NTMPAs) but highly relevant to the social dimensions of PAs in general, is "a set of rules that collectively

govern human interactions with a specified portion of the marine environment" (p. 166).

The spread of PAs over the last 30 years has been prodigious, and Juffe-Bignoli et al (2014) estimated that about 209,000 PAs cover 15.4% of the world's terrestrial and inland water areas, and 3.4% of the world's oceans. As the world inches closer to achieving the Convention on Biological Diversity (CBD)'s targets to protect 17% of terrestrial and inland water areas and 10% of coastal and marine areas by 2020, questions over the effectiveness of PAs have risen to the fore (CBD 2012). While quantitative targets for PAs provide ways of holding governments accountable, they also have the potential to promote quantity over quality, as the CBD's targets fail to provide clear metrics to account for factors such as ecological effectiveness, ecosystem services, biodiversity and representation (Spalding et al 2016). Some fear this may simply cause a push for the establishment of large PAs that push up numbers, but cannot be effectively managed (Joppa et al 2008, Wilhelm et al 2014, Agardy et al 2003). This could exacerbate the phenomenon of what have been termed "paper parks" – PAs that are therefore indistinguishable from surrounding areas (Joppa et al 2008, De Santo 2013).

Miller et al (2011) summarised the debate over the goals of protected areas as emerging from two groups: "nature protectionists," who advocate for biodiversity and ecosystem protection with strict limitations on human presence; and "social conservationists," who argue for sustainable use of resources in the context of social justice and poverty alleviation. The "nature protectionist" movement has been accused of enacting "fortress conservation" and alienating people from landscapes they knew and subsisted on (Brockington 2002). While the concept of "fortress conservation" was developed based on terrestrial examples, NTMPAs such as that established in the Chagos Archipelago have been accused of perpetuating similar problems by ignoring the rights of local people (De Santo 2011). For cultures that believe in the spiritual unity of humans and nature, the concept of PAs can be irrelevant or even harmful, as the ideal of an untouched landscape has resulted in the displacement of people who in fact lived there, particularly indigenous groups, and can disrupt the harmonious relationship between humans and nature (Cronon 1996, Sloan 2002).

The “social conservation” movement began to gain influence in the 1970s, formulating a version of conservation that allowed for sustainable human use and mitigated the negative impacts of PAs (Miller et al 2011). In practice, debates between “nature protection” and “social conservation” are often expressed through the level of resource extraction and community participation that different PAs incorporate in their regulations, establishment and management (Miller et al 2011). Levels of participation by different stakeholders are crucial to the sense of ownership that people feel over a PA, and so the management of these relationships can be crucial to PA effectiveness (Jones et al 2011). For example, MPAs can perpetuate social inequality through “elite capture,” where powerful voices protect and realise their interests, overwhelming marginalised voices (Christie 2004). Though many of these debates originated with terrestrial PAs, MPAs and NTMPAs are similarly torn in their purposes, with articulated goals bouncing between fisheries management and marine biodiversity protection.

Though they rarely possess the tools to vocalise struggles on a global scale, local communities around PAs are often subjected to a variety of negative impacts, including the loss of access to resources such as firewood or fish (Miller et al 2011). Costs of PAs may be active or passive (opportunity costs) which are felt differently at the local, national and global scale, and have most often been assessed in financial terms (Balmford et al 2003). The balance between costs and benefits may be different for different stakeholder groups. The martial mindset of protection can also result in conflict, as local people may suddenly find themselves categorised as “poachers” by the people carrying out conservation; interactions can become increasingly militarised, resulting in danger for humans on either side of the enforcement divide, as has been found in terrestrial reserves (Duffy 2014, Dudley et al 2013). This militarisation can also extend to the marine realm (Norton 2015).

The rise and spread of MPAs and NTMPAs

Though the use of MPAs in modern marine conservation has been heavily

influenced by the model established for terrestrial PAs, spatial forms of marine management have been in use over thousands of years by traditional fishing communities for ritual and fisheries management (Kenchington 1992, Johannes 1978). For example, on islands in the South Pacific, fishing areas could traditionally be declared taboo to mark a sacred occasion such as a funeral, to ensure a bountiful catch for an upcoming feast or celebration, or if the chief felt that the area had been overfished (Johannes 1978, p. 353). There is even evidence of marine spatial management in medieval Britain, through the banning of a destructive dredging device known as the *wondyrechaun* in certain areas (Philpots 1890).

The notion of marine protection for both fisheries and biodiversity purposes in the "developed" Western world only began to gain popularity in the late nineteenth and early twentieth century, when the vulnerability of marine ecosystems became clear. As Cushing (1988) wrote, "The sea has long provided food for men, but only in the last hundred years has the supply been threatened" (p. 294). The combination of vastly more efficient fishing methods in the developed world and exponential growth in the human population led to crashes in numerous fisheries and severe declines in the trophic integrity, functionality and biodiversity of marine ecosystems (Heithaus et al 2007, Worm et al 2007). By the estimates of Worm et al (2009), 63% of the world's assessed fish stocks currently require rebuilding.

In the late nineteenth and early twentieth century, most of the early MPAs in the developed world were established as part of terrestrial protected areas, though a few were designated for the specific protection of marine resources, as occurred in 1869 in the Pribilof Islands, off Alaska, for northern fur seals (Wells et al 2016). In 1958, as this movement was building, in an essay entitled "Our Ever-Changing Shore," influential biologist Rachel Carson wrote a plea for strict protection of the marine environment that drew on ideals of wilderness, saying, "We should set aside some wilderness areas of seashore where the relations of sea and wind and shore – of living things and their physical world – remain as they have been over the long vistas of time in which man did not exist" (Carson 1958, p. 124).

Since the 1970s, the spread of MPAs has been rapid. In 1974, a new world list of marine parks and reserves worldwide included 125 MPAs – mostly small, coastal areas – with many more in development (Björklund 1974). In 1986, this total had risen to around 430 MPAs (Silva et al 1986). Almost ten years later, Kelleher et al (1995) counted 1,306 MPAs worldwide, with an increasing number of large MPAs, and the IUCN proposed the creation of "a global system of marine protected areas to protect and manage representative examples of the world's rich marine biodiversity" (p. V). By December 2006, Wood et al (2008) reported a total of 4,435 designated MPAs, covering about 2.35 million square kilometres, or 0.65% of the world's oceans. 12.8% of this area, or 0.08% of the world's oceans, was strictly protected as no-take, or NTMPA (Wood et al 2008). By 2014, the number of MPAs recognised by the United Nations Environment Programme (UNEP) exceeded 12,000, covering just over 12 million square kilometres, or 3.4% of the world's oceans (Juffe-Bignoli et al 2014). The UNEP totals do not include areas such as Locally Managed Marine Areas or LMMAs, which have been designated by communities for fisheries management purposes (Juffe-Bignoli et al 2014).

There is great diversity in the MPAs currently functioning worldwide; size, ecosystems covered, management style, goals and activities permitted vary to the extent that "one could almost say that every MPA is unique, having been tailored to meet the specific circumstances of the place where it is established" (Agardy et al 2003). A dizzying array of terms has arisen to describe these variations; for example, Silva et al (1986)'s bibliographic listing of MPAs included 91 different categories of MPAs, including the subtle distinction between a "Natural Reserve" and "Natural Preserve." One problem in the categorisation and understanding of MPAs is that significant confusion can arise from the use of such a huge range of terms. For example, the term "sanctuary" is used to refer to multi-use MPAs in the United States, but has been used to refer to strictly protected no-take areas in the UK (Agardy et al 2003). MPAs have been advocated for a variety of purposes – most commonly, biodiversity conservation and fisheries management, but also poverty alleviation and a measure to buffer against the effects of climate change (Roberts 2012, Gjertsen 2005, McLeod 2009).

Despite this variation in terms, definitions and goals, differences between MPAs can be roughly understood through the four socio-political elements of marine reserve design identified by Pomeroy et al (2006) – resource use rules, arrangements for decision-making, monitoring and enforcement systems, and conflict resolution mechanisms. However, it is key to remember that the reality of these arrangements may differ from what is formally written, as informal and unwritten interactions are often key to the management of MPAs (Pomeroy et al 2006).

Resource use rules are key to the design of MPAs because they specify which people have access to marine resources (Pomeroy et al 2006). One of the clearest distinctions is whether an area is “no-take,” meaning that resources cannot be extracted from it, or whether it allows some form of resource extraction (Agardy et al 2003, Dudley 2008). If this is the case for the entire MPA, it is commonly referred to as a “no-take marine protected area” (NTMPA) or “marine reserve” (Mascia 2004). Extraction refers to the removal of resources that can include living creatures such as fish, molluscs, algae and other types of seafood, as well as inert resources such as oil, gas and sand, through activities such as fishing, dredging, harvesting, drilling or mining (Mascia 2004). In areas where resource extraction is allowed, other restrictions may be put into place, such as limitations on particular resources, gear, species, size, seasons, and total catch (Dudley 2008). As NTMPAs place the clearest and potentially most severe restrictions on resource users, they have been the focus of much debate and research (Roberts et al 2001, Agardy et al 2003, Rossetto et al 2015). However, the choice between extraction and non-extraction is not binary, as “multi-use” MPAs, which are increasingly common, can include areas in which resource extraction can and cannot occur (Dudley 2008).

Variations in decision-making arrangements refer to the rights of different groups of stakeholders – such as resource users, government officials, or MPA managers – to choose how a MPA will be developed and managed (Pomeroy et al 2006). The level of participation by different stakeholders in this process is key to the sense of ownership that people ultimately feel over the MPA, which can be important to setting the course

for its success (Jones et al 2011). These decision-making arrangements can be simplistically categorised as “top-down,” relating roughly to rules that are instituted from a higher level such as national government, “bottom-up,” relating to initiatives and decisions that emerge from communities, and “co-management,” which blends the two (Jones 2014).

The role of monitoring, or tracking changes in the MPA’s social and ecological systems, can be key in tracking MPA performance, as well as demonstrating benefits to stakeholders if they exist; however, many MPAs lack effective monitoring systems (Pomeroy et al 2006). Enforcement, or the use of sanctions to discourage people from engaging in prohibited activities, will be discussed in further detail in a later section. Enforcement plays a key role in ensuring compliance amongst resource users, and has been consistently identified as an important component in MPA success (Kelaher et al 2015, Watson et al 2015). Conflict-resolution mechanisms, or ways of settling disputes, provide an opportunity to clarify rules and move forward when disputes occur, though the distribution of power and openness of participation in these mechanisms can clearly impact their outcomes (Pomeroy et al 2006).

Costs, benefits and expectations for NTMPAs

NTMPAs, defined by Lubchenco et al (2003) as “areas of the ocean completely protected from all extractive and destructive activities” (p.3) are currently being used as tools to pursue goals related to both biodiversity conservation and fisheries management (Roberts et al 2012). Though NTMPAs can offer a high level of protection, they can also pose significant social difficulties (Lester et al 2009, Christie 2004). NTMPAs rely on the idea that relief from fishing pressure will allow marine organisms to grow in size and therefore fecundity, and this increased reproduction will lead to abundance and diversity spilling beyond the reserve’s boundaries to improve catch for fishing (Roberts et al 2001). In a TED talk entitled “Glimpses of a Pristine Ocean,” Sala (2010) compared NTMPAs to bank accounts: “What we have now—a world without marine reserves—is like a debit account where we withdraw all the time and we never

make any deposit. Reserves are like savings accounts."

Despite the economic case made for NTMPAs, the rationale behind them is often attributed only to biodiversity conservation, as fishing is often unequivocally described by conservationists as damaging to the marine ecosystem (Halpern et al 2010). Indeed, Koldewey et al (2010) refer to fishing as the "largest anthropogenic threat to pelagic ecosystems," and point to its prevention as the greatest potential benefit for an ecosystem (p. 1910). However, meeting biodiversity and fisheries goals may not be mutually exclusive, as Gjertsen (2005) argues that NTMPAs may be able to meet environmental and development goals. In 2001, the National Centre for Ecological Analysis and Synthesis (NCEAS) released a scientific consensus statement on marine reserves signed by 161 leading marine scientists and experts on NTMPAs, calling them a "highly effective but under-appreciated and under-utilised tool," and stating that full protection (or no-take status) was necessary to realise all benefits, including adequate enforcement and public involvement (pp. 1-2). Overall, NTMPAs have been lauded for their biodiversity benefits but questioned for their fisheries benefits and social impacts (Caveen et al 2015, Christie 2004).

Biodiversity & fisheries benefits

In an interview from 2012 cited in Caveen (2015), Dan Laffoley, Vice-Chair of the World Commission on MPAs, claimed "there is no better tool for recovering marine biodiversity than marine reserves" (p.3). A meta-review of 149 peer-reviewed papers on marine reserves conducted by Lester et al (2009) showed a consistent increase in the density, species richness and size of organisms within the boundaries of NTMPAs. The study also found that benefits of NTMPAs were realised in temperate as well as tropical marine systems, that even small NTMPAs could have benefits, and that species responses to NTMPAs varied by mobility and size. Ruttenberg et al (2013) echoed the point that reactions to NTMPAs can be species-specific, depending on the size and migratory potential of the organism in question. Various examples of success in NTMPAs can be found in the academic literature. In the Cabo de Palos NTMPA in

Spain, the abundance of dusky grouper increased 4000% following eleven years of protection (García-Charton et al 2008). In Cabo Pulmo National Park, a NTMPA in Mexico, Aburto-Oropeza (2011) showed a 463% increase in fish biomass four years after its establishment.

Though it is relatively established that NTMPAs lead to increases in fish abundance within their borders, greater controversy exists over the situations in which marine reserves create sustainable fisheries, and the situations in which fisheries regulations might be more effective (Hilborn et al 2004). The concept of spillover, or whether the marine organisms protected in NTMPAs and their offspring will migrate to areas where fishers can access them, is key to answering this question (Hilborn et al 2004, Roberts et al 2012). There is evidence of spillover; in Florida and St. Lucia, NTMPAs were found to boost nearby catches by between 46 and 90%, depending on the types of fishing gear used (Roberts et al 2001). Goñi et al (2010) documented spillover of lobster larvae and larger lobsters being caught by fishers at the edges of the NTMPA; however, this spillover did not completely compensate for the loss of fishing grounds. In a study conducted in Mombasa Marine Park in Kenya, McClanahan et al (2000) found that even when spillover occurred, it did not compensate for the loss of fishing grounds and total catch was still reduced overall. In a study of NTMPAs carried out in Kenya and the Seychelles, Cinner et al (2014) found that in 90% of fishers reported catching fish that they believed had spilled over from a NTMPA, while Rossetto et al (2015) highlighted the role of NTMPAs in increasing both abundance and commercial yield of abalone.

Social costs

Bergseth et al (2015) writes, “Marine reserves are essentially human-exclusion experiments.” While this may be true in terms of a textbook definition, social components of a NTMPA are crucial to its biological success because the success of a NTMPA depends on people deciding to follow its rules (Mascia 2004). If a NTMPA is not socially accepted, even low levels of illegal fishing may keep it from achieving its goals, and ultimately render it a paper park (De Santo 2013). The establishment of a NTMPA, which prohibits extraction of resources, can have significant negative impacts on the

people who live around it by restricting their access to important food and livelihoods (Cinner et al 2014, Voyer et al 2015). An estimated 12% of the world population are reliant on fisheries and aquaculture for livelihoods, and particularly in the case of developing countries and subsistence fishing, access to the marine ecosystem can mean the only steady supply of cheap, high quality protein (FAO 2016, Aswani et al 2007). Marine-related activities such as fishing can also be of high cultural and social importance, particularly in the case of indigenous peoples (Amberson et al 2016, Thornton et al 2015). Christie's (2004) study of four MPAs in Indonesia, three of which were fully no-take and one of which contained small no-take areas, pointed out that MPAs could simultaneously be biological successes, with increased fish abundance, biodiversity and improved habitat, but social failures.

Compliance & enforcement

As is the case with many undertakings, any costs and benefits of marine and terrestrial PAs are unlikely to be realised unless the regulations set out for them are respected by resource users. A lack of compliance, or adherence to rules and regulations, has been identified as a significant hurdle in protected areas worldwide (Stern 2008). Compliance differs from enforcement, and the one does not necessarily follow from the other. Enforcement can generally be divided into two categories: the use of coercive policing strategies such as patrolling and applying penalties to deter illegal resource use, sometimes known as "hard" enforcement, and the use of education and consensus-building mechanisms to build legitimacy and voluntary compliance within a community, known as "soft" enforcement (Stern 2008, Pendleton 1998). The idea that "hard" enforcement by PA guards or enforcement agents is successful in deterring illegal resource users is implicit in the management of many PAs (Stern 2008). The use of martial language around PAs, including phrases such as working on the "front lines" of conservation and metaphors of PAs as islands besieged by external threats, can set the stage for "hard" enforcement being thought of as the default (Miller et al 2008). Given the punitive associations of the word enforcement, which is often associated only with "hard" enforcement, Knott (2013) suggested the use of the term "compliance management," with enforcement being one tool of many used to foster voluntary

compliance.

Enforcement of terrestrial and marine protected areas can be extremely expensive, and because resources in conservation are often limited, there is significant debate about which enforcement methods and types are most effective and cost-efficient (Plumptre et al 2015, Kelaher et al 2015). Akella et al (2004) conceptualise enforcement of PAs as a chain with four stages – 1. Surveillance & Detection; 2. Interception & Arrest; 3. Prosecution; and 4. Sanctions – emphasising the holistic nature of enforcement and the importance of completing each stage without "breaking the chain." Rosero (2010) adapted the use of this framework for MPAs. Though they noted a severe lack of systematic data collection around enforcement, Akella et al (2004) suggest that Stage 1 and 2 are likely to be affected by incentives given to enforcement officers and available equipment, and Stages 2, 3 and 4 by the quality of evidence collected and social attitudes toward a crime.

Assumptions behind enforcement of PAs are often based on the basic deterrence model developed to understand criminal behaviour, which assumes that a self-interested individual decides whether or not to comply by weighing up the likelihood and the severity of sanctions, with the potential gain from the illegal action (Kuperan et al 1998). It should be noted that local resource users who are subject to changes in regulations in areas they have formerly frequented are not necessarily criminals. However, if there is a low probability of being caught – as is the case with many MPAs, due to their size, inaccessibility and restricted resources for enforcement – then this theory suggests severe and certain penalties must be enacted to dissuade potential resource users (Kuperan et al 1998). This is far from the case in many MPAs, which may contribute to high levels of non-compliance (Mora et al 2006, Kaplan et al 2015). However, Kuperan et al (1998) report that although the likelihood of being caught is very low, at below 1% according to their generalised calculations, 50-90% of fishers comply with regulations, with many citing a desire to do "the right thing" as the reason. This gives an indication of how important social processes and norms are in enforcement and compliance of PAs.

Theory associated with the use of common pool resources, open to exploitation by any person with the means to do so, is particularly relevant to compliance in MPAs and NTMPAs, though much of it was developed around terrestrial systems such as forests. The marine system has traditionally been conceived of as a common pool resource, subject to the "tragedy of the commons" described by Hardin (1968), by which degradation occurs due to the short-term incentives associated with individual gain in the context of collective action (Ostrom 1990). However, Ostrom (1999)'s work indicates there is hope in the collective management of these commons, through participatory processes that incorporate local knowledge and institutions. The buildup of cooperation can lead to an "upward spiral" of trust and legitimacy; conversely, breaches in trust or cooperation can lead to a "downward spiral" (Ostrom 1998). Therefore, consultation of stakeholders and participative processes in establishing and managing MPAs can be key to their success and to the compliance of local resource users, but rarely occur to the necessary extent (Jones et al 2013, Voyer et al 2015).

Academic scholarship on enforcement in PAs has increasingly focused on voluntary compliance as the ultimate goal of enforcement, and perceptions of legitimacy are key to this goal (Stern 2008). A study conducted by Stern (2008) found perceptions of trustworthiness of PA managers were the most consistent predictors of "exercised restraint," a form of voluntary compliance, on behalf of people living near three terrestrial PAs. According to Ostrom's theories, legitimacy created through cooperation is absolutely key; when resource users consider rules for a common-pool resource to be legitimate, they are frequently willing to comply with these rules and even carry out enforcement such as monitoring and sanctioning, even when a resource is state-owned (Ostrom et al 2007). The use of both positive returns and negative sanctions through enforcement, where appropriate, is key to success (Ostrom 1999). This is important because the enforcement of rules that are perceived as illegitimate by local stakeholders can result not only in non-compliance, but in violent conflicts around protected areas (Stern 2008). An example is that of conflicts around fishing regulations in the Galapagos Marine Reserve, which resulted in a violent uprising by fishers, who took over the Charles Darwin Research Station (Schrope 2000).

Importance of compliance & enforcement in MPAs and NTMPAs

Compliance with regulations has been identified as key to carrying out effective marine conservation and meeting MPA objectives, as well as maintaining social credibility with stakeholders (López Ornat et al 2015). Because even a small amount of unauthorised fishing can significantly affect the productivity of an MPA, Jennings (2009) claims a lack of compliance and support for enforcement has compromised achievement of goals in many MPAs. While compliance has been identified as a key component of MPA success, it is often not monitored or measured in MPAs, and quantitative data on compliance can be hard to find (Read et al 2015, Bergseth et al 2015). Kelleher et al (1995) determined that only 31% of MPAs were generally achieving their management objectives, citing a lack of compliance, due to insufficient involvement of local communities in the establishment of rules, and a lack of enforcement as two reasons. Almost twenty years later, Rife et al (2013) echoed these sentiments in an assessment of MPAs in the Gulf of California, finding that MPAs were not meeting their conservation or sustainability goals, with the exception of one, and citing a lack of enforcement, insufficient no-take areas, and a lack of community involvement as reasons. Bergseth et al (2015) claim that “non-compliance is often the rule rather than the exception” (p. 241) and research conducted by Mora et al (2006) found that less than 10% of the world’s marine reserves are regulated in a way that can effectively curb the infringement of rules.

Nonetheless, compliance and enforcement have been identified as important factors in the ecological success of MPAs. In an analysis of 87 MPAs worldwide, Edgar et al (2014) identified efficient enforcement and no-take regulations as two of five key components that exponentially increase conservation benefits. In Cabo Pulmo National Park, described by Aburto-Oropeza et al (2011) as “the only well-enforced no-take area in the Gulf of California, mostly because of widespread support from the local community,” fish biomass had increased by 463% four years after its establishment, and the biomass of top predators increased eleven-fold (p.1). In Australia, Kelaher et al (2015) found that greater enforcement in no-take areas in the Cape Byron Marine Park over 3 years, with a 201% increase in annual fine rate, led to a significant increase in

target fish species, including sharks. A meta-analysis of 63 no-take areas, for which compliance levels and fish biomass data could be reliably determined, showed that compliance data predicted reserve response ratios of target fish biomass (Bergseth et al 2015). Robbins et al (2006) compared shark densities in fished zones, strictly aerially enforced no-entry zones on the Great Barrier Reef, where vessels are not allowed, and no-take zones, where vessels are allowed to anchor though fishing is prohibited. Fished zones contained 80% fewer whitetip reef sharks and 97% fewer gray reef sharks than no-entry zones, but fished zones and no-take zones were almost indistinguishable, leading Robbins et al (2006) to the conclusion that illegal fishing due to a lack of enforcement was negatively impacting shark populations.

Kaplan et al (2015)'s study of MPAs in the Greater Caribbean region found that MPAs with greater incentives and penalties incorporated in their management systems had higher density and biomass of commercial fish. However, social dynamics around enforcement and compliance are undoubtedly complex, and Pollnac et al (2010) found that compliance levels in 127 marine reserves, or NTMPAs, were related to contextual social interactions, including political, economic and cultural conditions, rather than levels of enforcement.

Practicalities of enforcement in MPAs and NTMPAs

Carrying out enforcement in MPAs carries unique challenges, such as navigating a fundamentally foreign environment using boats and expensive technology, but also benefits, as it can be easier to spot people (Sloan 2002, Kelaher et al 2015). Running costs for MPAs vary widely according to size, distance from inhabited areas, and whether they are located in developed or developing countries (Balmford et al 2004). Funding is often limited; in a survey of 83 MPAs, 15.7% of MPAs reported that current funding sufficed to carry out effective conservation (Balmford et al 2004).

López-Ornat et al (2015) claim surveillance, traditionally taking the form of boat patrols, is often the most expensive enforcement management activity in MPAs, and therefore suggest alternative tactics such as patrols from shore to lower costs and

increase personal interaction with resource users. The use of technology such as satellite monitoring and drones has received much attention due to the potential to expand surveillance and detection of illegal resource use at a low cost (López-Ornat 2015). Evidence provided by Saenz-Arroyo et al (2005) suggests that communication is crucial in ensuring compliance. In NTMPAs established in Loreto Bay, in Mexico, a communication programme consisting of the distribution of pamphlets, posters and signs, as well as talks to the local community, increased the percentage of users that could correctly locate the park's boundaries from 13% to 73%, and boundaries for no-take areas increased from 13% to 50%; following the programme, compliance in no-take areas increased from 67% to 88% (Saenz-Arroyo et al 2005).

Monitoring of compliance and enforcement in NTMPAs can be simpler than in areas with limitations on factors such as gear type, time restrictions, species, size or catch allowances, for the simple reason that anyone fishing in the area is clearly breaking the rules, so violations are easier to detect (Bohnsack et al 2004, McClanahan & Mangi 2002). It is worth noting that processes of enforcement in NTMPAs are likely to differ depending on governance type; for example, a community-based MPA is likely to have different processes for sanctioning and penalties than will a highly militarised MPA established by the national government.

Human costs of enforcement & compliance in NTMPAs

NTMPAs can impose very real social costs on local resource users who choose to comply, and an understanding of these costs is key to improving marine governance and NTMPA effectiveness (Sanchirico et al 2002). Research on this subject has largely focused on impacts on fishers and resource users (Cinner et al 2014, Coulthard et al 2009, Smith et al 2010). When fishers are displaced by a NTMPA, they face immediate costs – such as increased fuel costs, reduced catch, and increased competition with other fishers – but are generally promised benefits over time (Cinner et al 2014). Fishing is already one of the most dangerous professions in the world, and displacement can also increase safety risks through fishers having to go to sub-optimal, more distant, or less well known areas (Sanchirico et al 2002). Fishers may also face issues of food

security (Mascia et al 2010). The severity of these costs appears to be differential, varying by target species, gear used, skill and experience, and availability of alternative income, and may be direct costs or opportunity costs (Smith et al 2010). The establishment of NTMPAs may also impose psychological costs on resource users, such as increased crowding and conflict, and the stress of uncertainty for the future (Dobrzynski et al 2002). NTMPAs can affect social structure by altering standards of living for local communities, which can lead to increased levels of crime and drug abuse (Mascia 2004). A study conducted by Basurto et al (2016) in Baja California Sur, indicated that MPAs which include NTMPAs heightened social interactions amongst fishers, as fifteen years after establishment, there was higher prosociality and antisociality (cooperation and competition) in areas with MPAs than without them. Costs to fishers are not always taken seriously; as Smith et al (2010) writes, “Advocates for marine reserves often treat fishermen’s assertions about the costs with the same skepticism that fishermen have for the stated benefits” (p. 18301). Costs can also be cultural, as fishing can be tied in with traditional beliefs, practices, knowledge and values, particularly in the case of indigenous groups (Amberson et al 2016).

Understanding the social costs of NTMPAs to all stakeholders is key to approaching their establishment and working toward their success (Sanchirico et al 2002). When voiced through appropriate channels, conflict can be taken as an opportunity to improve marine governance and provide options such as alternative livelihoods, which can give local resource users alternate sources of income (Sievanen et al 2005).

Despite the established importance of social interactions creating effective marine and terrestrial PAs, and the key role of enforcement, little research has been carried out on the social implications of enforcement in marine reserves, for enforcers, legal or illegal resource users. However, enforcement does not happen in a vacuum; rather, it is carried out by and affects people who take on the roles of resource users, managers and enforcement agents. Akella et al (2004) hint at the importance of these costs by stating that fear can play a significant role in the effectiveness of enforcement, and that weaknesses in the chain of enforcement are generated when enforcement agents, including wardens, prosecutors and judges, “fear negative repercussions from doing

their jobs properly or when they are intimidated or co-opted by those breaking the law" (p.10).

The human costs of militarising terrestrial PAs under the flag of conservation have begun to receive attention on land, in particular assessing the role of "poachers" or illegal resource users, who may be local individuals with few options drawn into a larger conflict (Duffy 2014). When speaking of illegal resource use, Duffy says the effects of rhino poaching are "much wider than the act of hunting and killing the rhino itself—there are very clear human costs that are often rendered invisible in the headlines" (p. 825).

The case for human costs can also be argued for the marine realm, and has been assessed in the academic literature for South Africa, where MPA enforcement is highly conflictual (Hauck 2008, Schultz 2015, Norton 2015, Rogerson 2015). When speaking of one South African MPA, Norton (2015) claims "inspectors are expected to do a job that the very construction of the job in itself prevents them from doing" due to social pressures, bureaucracy and violence (p. 338). Rogerson (2015) argues that different conceptions of the marine environment are created by enforcers and resource users, leading to misunderstandings. Mentions of violent conflicts between enforcement agents and resource users can readily be found in the media and in some academic literature, from Palau to Indonesia, but they have received little focused attention or discussion (Jones 2014, Schrope 2000). Evidence of the human costs of enforcement also exists for community-based MPAs. When part-time fishers carry out enforcement in Mexico, as is common in developing countries with little oversight, they face social pressure in reporting their peers, with one interview subject stating "[Nobody wants] to have enemies at the sea" (Nenadovic et al 2016).

METHODS

In order to identify and measure human costs of enforcement and compliance in NTMPAs, I conducted key informant interviews with experts who had significant experience of with the establishment and/or management of NTMPAs. I also conducted an online survey to gather quantitative information and examples of human costs of enforcement and compliance in NTMPAs from a broader group of people with a range of experiences and geographical locations.

1. Key informant interviews

Key informant interviews are an established technique in social research, used to gather information about a topic by conducting in-depth interviews with people selected for their specialised knowledge or expertise (Tremblay 1957). In order to gain a greater understanding of human costs of enforcement and compliance in NTMPAs, between August and October 2016, I carried out semi-structured key informant interviews with 20 key informants: 7 academics with experience of studying MPAs, 3 MPA managers, 1 fisher, 6 NGO practitioners, 1 environmental psychologist, and 2 former MPA wardens/enforcement agents with over a decade of enforcement experience. I chose to focus on NTMPAs rather than MPAs in general because enforcement is clearer in NTMPAs (McClanahan & Mangi 2006).

I identified experts in the establishment and/or management of MPAs based on relevant scientific publication history or their publicly identified role working in or near a NTMPA. I wanted to ensure that my key informants' expertise included those with practical experience of NTMPA enforcement and management, experts in social and ecological science of NTMPAs including work on indigenous communities, and members of communities affected by NTMPAs.

I contacted most participants via email, and one participant via telephone. I sent participants a key informant information sheet (Appendix 3), and confirmed consent prior to the interview using a pre-prepared oral consent script. I decided on oral consent as opposed to written, because many of the individuals I interviewed were extremely

busy and I decided the logistics of signing a consent form remotely could be prohibitive.

I carried out 17 interviews in English and 3 in Spanish, based on the preference of the interviewee. I felt confident carrying out interviews in both languages because I am bilingual in English and Spanish, and wanted to ensure that participants could express their opinions and experiences as freely and clearly as possible. Key informant interviews were conducted over Skype, on the phone, or in person, and I took handwritten notes and audio recorded. I had a list of questions that I asked most of the participants (Appendix 4) but given limited time, I occasionally digressed to ensure I captured participants' particular expertise. Interviews lasted approximately one hour on average.

Following each interview, using the audio recording, I coded each interview into a time-stamped outline, colour-coding the identification of different human costs and the groups affected them, as well as transcribing key quotes. Following the conclusion of this coding process, I compiled a list of the coded costs and groups into a complete list of costs, together with relevant quotes and examples. I then thematised human costs into 18 groups based on how they impacted different stakeholders, and presented them in a table along with examples. Following this process, I created diagrams using the programme Scapple to showcase these costs, the groups they impact, and the relationships between different costs.

2. Online survey

Surveys are often used as a research technique to gather quantitative data on an issue, and the use of internet-based surveys is becoming increasingly common due to their convenience and accessibility (Tremblay 1957, Fricker 2012). Sampling for online surveys can be probability-based, so respondents are selected using a probabilistic mechanism and the probability of including any member of the survey's accessible target population is known, or non-probability-based (Fricker 2012). Non-probability sampling is commonly used when the target population is prohibitively expensive or

difficult to reach, and is less reliable for statistical inference (Fricker 2012).

Distribution

In order gather quantitative information about the prevalence and distribution of human costs of enforcement and compliance in NTMPAs, I prepared and distributed an online survey (Appendix 1). The survey was created using a SurveyMonkey Gold account, and revised with three experts in the use of social surveys prior to publication. I made the survey anonymous, because I thought people would be more willing to speak frankly about the sensitive topic of human costs of MPA enforcement and compliance. The survey was available online for 30 days and received 173 responses, of which 75 were completed and therefore valid for analysis.

Respondents were recruited through non-probability sampling, in a combination of snowball sampling (by asking acquaintances and key informants knowledgeable about NTMPAs to distribute the survey) and judgment sampling (by identifying online communities such as mailing lists and professional groups likely to contain members of the target population: people with experience of NTMPAs, either as local community members, enforcers, managers, academics, etc). The online survey was distributed through a variety of channels, seeking individuals with experience in use, establishment or management of NTMPAs. My supervisor and I shared the survey on Twitter and asked those in our networks to do the same. I posted about the survey in several Facebook and LinkedIn groups with relevant themes, such as groups focused on marine conservation and marine protected area management, including the Marine Protected Area Governance (MPAG) group. The survey was included in the Pew Charitable Trusts' October newsletter for Marine Fellows. Finally, I identified specific NTMPAs and found contact information for managers through online research, and sent them personalised emails asking them to fill out the survey. I also asked my key informants for their help in distributing the survey, and posted about the survey on relevant electronic mailing lists ("list servs") circulated through the marine ecology and conservation and fisheries management communities, including FishFolk, Coral List, GCFI, CAMPAM, and GLISPA.

Survey structure

Before respondents could access or complete the survey (Appendix 1), they were asked to read an information sheet about the study and consent to participation, including that once they submitted their responses they would be unable to retract their data because the survey was anonymous. The survey was structured so that each respondent was giving information about a specific NTMPA, so that responses could later be analysed as sample units of individual NTMPAs. Because the survey was distributed through non-probability sampling, I included questions to gauge the respondent's experience in terms of time and role in the MPA (academic advisor, manager, tourist, etc). The survey had four sections: MPA Characteristics; MPA Management; Enforcement & Compliance; and Human Costs of Enforcement & Compliance. I referred to "MPAs" in the survey rather than "NTMPAs" because some MPAs were only "no-take" in some areas, and provided defintions for no-take areas as well as stakeholder types, enforcement and compliance.

The Characteristics section covered the location, size and percentage of no-take area included in the MPA, as well as respondent characteristics. The Management section covered MPA purpose, activities allowed, age and active management time for the MPA, challenges for the MPA, and stakeholders involved in the MPA currently and in the past. The Enforcement & Compliance section covered enforcement priorities in the MPA, identification and ranking of methods of enforcement used in terms of expense, effectiveness and popularity, and levels of respect and compliance for the MPA from different groups. Finally, the Human Costs of Enforcement & Compliance section asked respondents to identify which human costs were present in their MPAs, give examples of situations where they had witnessed human costs, and provide measures to improve MPA effectiveness in terms of enforcement and compliance, if they had any.

Analysis

I carried out all analyses on survey data using Excel and R Studio (Version 0.99.903). I created histograms to characterise the online survey data by respondent type and MPA size, age, and purpose. I also created spider diagrams to show the spread of types of human costs reported to impact different groups (enforcers, illegal resource users, and legal resource users) and charts to demonstrate the effectiveness, popularity and expense of different enforcement methods.

RESULTS:

20 key informants and online survey respondents from 34 countries reported a wide variety of human costs of enforcement and compliance in NTMPAs, impacting managers, enforcement agents, legal and illegal resource users in their personal and professional lives. I will first present the findings of the key informant interviews, and then quantitative data from the online survey.

Key informants are categorised in the following way: Academic (A), NGO practitioner (N), NTMPA management (M), Fisher (F), Warden/Enforcement agent (W), and Environmental psychologist (P). Key informants were also assigned numbers to distinguish them.

Key Informant Interview Results:

Through 20 key informant interviews with experts ranging from academics to NGO practitioners, former wardens, MPA managers and an environmental psychologist, I gained a deeper understanding of the roles of enforcement and compliance in NTMPA effectiveness and identified a total of 18 human costs of enforcement and compliance in NTMPAs, which can be roughly categorised as material, physical, psychological and social. These costs often affect managers, enforcement agents and resource users on either side of the enforcement or legality divide, and their categorisation takes account of the fact that resource users can play roles in both enforcement and compliance, and suffer the costs of playing either role.

Understanding human costs

Almost all key informants agreed with the statement that the human costs of enforcement and compliance in MPAs are less well understood than the benefits, and stressed the importance of understanding the role of human costs in enforcement and compliance in NTMPAs. As one academic said, “At the end of the day, this whole conservation thing is a human process, it’s not just about animals… You don’t manage

the number of [sea] cucumbers, you manage the number of humans" (A8). An MPA manager echoed this point, saying "conservation work is really people work" (M11). Numerous key informants dwelt on the role of conflict and antagonism in NTMPAs, and the social segregation between enforcers and resource users, which some saw as contributing to human costs of enforcement and compliance. As one NGO practitioner said, "There's a lack of integration in the social network that includes fishermen, and the social network that includes the wardens of the MPA. If they become isolated from each other, and don't have many interactions, they start to behave as enemies of each other, as one against the other" (N1). A former warden said, "Confrontation really is dangerous, really dangerous. Because it just sets up opposition, and not willingness to debate, talk about and laugh together, and be part of a system that is working for the common good." (W12). One MPA manager gave an example to illustrate a potential solution to this problem, explaining that he holds meetings every week for fishers to come in and discuss concerns. Various key informants discussed the role of human interactions in enforcement actions, with one NGO practitioner saying, "It really comes down to the human element and the rule of law, and whether it will be enforced" (N4). Training of enforcement officers was identified as a key element in successfully conducting these interactions. One academic made a clear link between warden compensation and MPA effectiveness, citing an example he had seen in Vietnam, where wardens were underpaid and therefore sold petrol and fishing access to local fishers (A3).

Some key informants noted the potential role of NTMPA enforcement in creating or perpetuating social inequality; as one NGO practitioner said, "Whoever benefits most is probably the people who are most interested in enforcement" (N5). A number of key informants spoke of problematic designations when it came to legal and illegal resource users, with one academic saying, "In general, there is a matter of social injustice. The state creates a reserve, and suddenly people are 'illegal fishers'… But migration is natural" (A19). Various key informants noted the further role of poverty and desperation in some cases of illegal fishing, saying, "Poaching is done out of desperation or resentment… if alienated, burden on protector" (A7). Key informants with experience of working with indigenous peoples particularly noted the severity of cultural costs in

NTMPAs, including the lack of flexibility around sustainable long-term use, as well as the aggravation of historical tensions relating to different world views around the sustainable management of marine resources.

Several key informants spoke of the difficulty of convincing people to act within the regulations of a NTMPA, and overcoming literacy difficulties as well as negative perceptions of MPAs. Some key informants spoke of the need for marine ecosystems to crash or be completely depleted before communities were willing to consider respecting or implementing a NTMPA. One academic summarised this problem in the following way: “The problem solved itself… We didn’t have to keep running around after people, because the cucumber fishery crashed. They shot themselves in the foot. There isn’t a solution until extraction hits rock bottom… There is very little understanding of long term interest” (A8).

Role of enforcement and compliance in NTMPAs

Key informants provided various points of view about the role of enforcement and compliance in creating and managing effective NTMPAs. As one NGO practitioner said, “A no-take MPA is only as effective as its ability to restrict fishing” (N5). Almost all key informants stated that enforcement was important; one NGO practitioner said, “Enforcement is 100% critical.” Many key informants clarified that in practice, enforcement actions should only apply with a small subset of the population; as one NGO practitioner said, “You can rely on a certain percentage of people to do the right thing… some don’t know, some willingly break the law” (N6). In general, heavy-handed enforcement in a non-compliant community was discouraged as human costs can dramatically increase; as one NGO practitioner said, “You can’t just come in with blazing guns. That’s a recipe for backlash” (N4). A few key informants suggested that if a large sector of the population is not complying with the rules, policies should be reassessed or at least reviewed; as one academic said, “It’s important to realise that, when people don’t comply with the rules, there is an interesting reason why. It’s not just because they’re ignorant or selfish. That could be part of it, but generally non-

compliance is indicative of other issues" (A10). Another academic echoed this point, saying, "Very strict enforcement can actually ramp up the injustices if it's badly designed rom the outset and badly executed" (A3).

Numerous key informants were cautious of the word "enforcement," clarifying that they viewed it as a way to foster compliance, with "soft approaches" such as education, good relations with communities and well-crafted rules being the first priority. One NGO practitioner said, "When it comes to enforcement, people think of hard measures and not soft measures enough. Education and outreach can't be stressed enough in terms of just everyone understanding what is and is not permitted" (N4). One academic spoke of the idealisation of enforcement in MPAs as a "utopia" that focuses on increasing equipment and capacity rather than community engagement, adding, "Since budgets are limited, you need to decide whether to put money into enforcement or education… Sometimes enforcement wins, and so other processes that might be more important in creating compliance don't get done" (A17). A number of key informants also pointed out that the role of enforcement is often very different in developing countries – where resource users can be illiterate and extremely poor, depending on the sea for food, and top-down enforcement capacity can be either non-existent or highly militarised – and developed countries. As one academic said, "In developing countries, costs are more violent and radical. In developed countries you have a higher educational and technological starting point" (A8). In developing countries, community members may need to take on enforcement activities themselves, because "the government will never dedicate the resources to carry out enforcement there" (A17). Key informants gave several practical examples of the human costs of enforcement and compliance impacting MPA effectiveness; however, one given by an academic gave a particularly clear link: "The people in Magdalena, they gave up on the project because doing enforcement was just too hard. There was violence, illegal fishing. A marine reserve is like a piggy bank… And people got tired. They decided, I'd rather break my piggy bank and go and eat hot dogs" (A19).

Identification of human costs

Key informants identified a wide variety of human costs of enforcement and compliance, demonstrating that these costs expand far beyond the monetary costs that are most often reported and discussed. It is likely that some of these costs, such as those relating to physical harm, financial stress and nutrition, play into individual decision-making around effective enforcement and legal or illegal resource use. This link was clearly articulated by one key informant, who said, “My background as a psychologist tells me if they don’t believe the measures are effective then they’ll be less likely to stay out of the MPA” (P18). Compliance costs are based on the assumption of displacement, as NTMPAs do not allow resource extraction of any kind. The variety of costs identified by key informants gives a sense of the complexity of the social dimensions of NTMPA enforcement and compliance, but also provides jumping off points for mitigation and potential solutions.

Costs are illustrated in the following figures and tables (Figs 1a-b, Table 1, Table 2). They are broken down into costs of enforcement and compliance, identifying cost type, the cost itself, groups affected, and an example of the cost. In Figs 1a-b, arrows are used to indicate causality based on key informant interviews, whereas dotted lines are used to demonstrate links and italics provide further explanation if necessary.

Fig 1a. Human costs of enforcement in NTMPAs

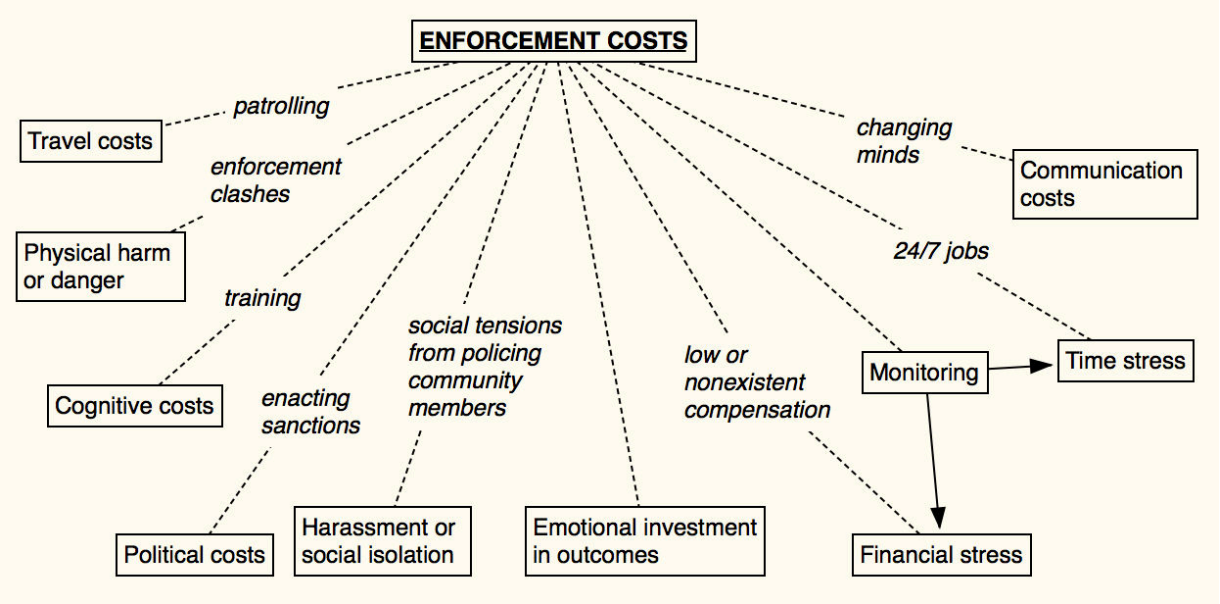


Fig 1b. Human costs of compliance in NTMPAs

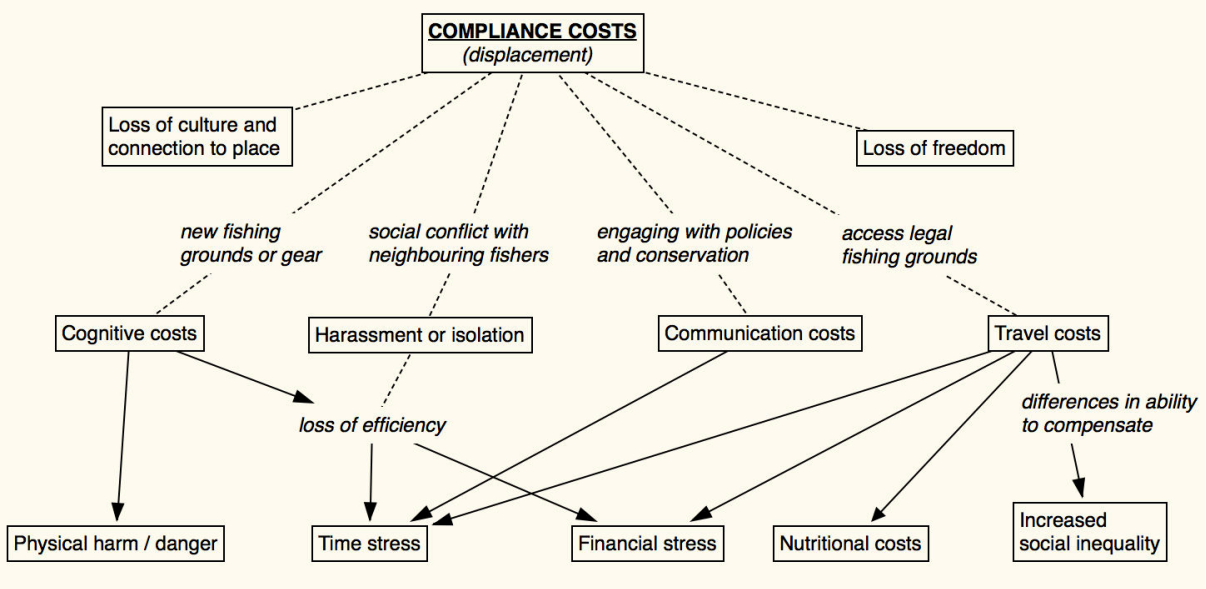


Table 1. Human costs of enforcement

Cost & type	Group affected	Example
Physical harm or danger	Legal resource users	"If you tell on someone… They can come and hurt you or hurt your family" (M14)
	Illegal resource users	"When somebody saw the [MPA enforcement agents coming] they jumped into the water and they drowned" (M14)
	Enforcers (wardens)	"[Illegal fishers] shoot bullets into their boats" (A19)
Nutrition	Illegal resource users	"Most of the people who are poaching say they need to do it to feed their family" (M14)
Travel	Enforcers	"It takes 13 hours to just get to the marine monument, at $15-20k per hour. It's a catch 22. You don't know what's out there, so it's not worth sending a plane" (N6)
Financial stress	Illegal resource users	Fines can impact illegal resource users' financial situations, which may already be desperate, particularly if they have debts.
	Enforcers (wardens)	"The wardens are underpaid, so they are effectively subsidising our enforcement by working under what they should be earning, and also sometimes with inconsistent pay" (M11)
	Enforcers (management)	"I'm the chairman of the board but I don't get paid, I've never been paid. I get paid expenses if we've got money in the pot to pay expenses… all the costs came out of our own pockets." (N9)
Emotional investment	Illegal resource users	"Poaching is done out of desperation or resentment" (A7)
	Enforcers	"If someone violates the sanctuary, it feels very personal" (M11)
Cognitive	Enforcers (management)	"Everyone who works on this is coming from a different sector, so there is an educational cost to transferring technology" (A8)
	Enforcers (wardens)	"Most people have no experience of marine law enforcement at all." (W15)
	Illegal resource users	"The most chance of anybody doing anything wrong is through ignorance, and that's usually a holidaymaker putting out a couple of creels to catch for themselves, but that can usually be sorted out without any kind of heavy-handed enforcement" (F20)
Communication	Enforcers (management)	"People are illiterate or nearly illiterate… need to explain marine ecology, explain MPAs" (M14)
Time stress	Enforcers	"We have to get up in the middle of the night if we see someone poaching - no one wants to do that" (M14)
Social isolation	Enforcers (wardens & management & community members)	"The cost to the wardens and to the people who have to apply the law is daunting, from an emotional and mental point of view. They don't like it. And sometimes, of course, it can end up with people turning blind eyes to what's going on out there because they can't take the strain and stress of having to tell their friends to shift." (W12)
Monitoring costs	Enforcers (management)	"We could get a lot more buy-in from the public if we could show them more clearly the long-term benefits to them" (P18
Political costs	Enforcers (management)	"Corruption is massive. Most of the illegal fishers will have a donor, who is a wealthy person who supports them and actually makes the money out of it. Those people are very powerful and could get somebody out of prison, and apply a lot of pressure. These sorts of challenges are a lot more difficult to overcome." (N2)
Harassment	Enforcers (management)	"I was attacked in an airport by someone who recognised me… verbally assaulted right in middle of public… that's uncommon but it's more common to have harassing telephone calls, threatening written communications away from meetings" (P18)

Table 2. Human costs of compliance

Cost	Group affected	Example
Physical harm/danger	Legal resource users	Adjustment to fishing in new places or using new types of gear can put resource users in danger; for example, collecting gull eggs on unfamiliar cliffs (A7)
Travel	Legal resource users	Legal resource users may need to travel further to access legal fishing grounds, requiring extra fuel and ice to preserve fish.
Nutrition	Legal resource users	Legal resource users may lose access to food security and a source of cheap, high-quality protein (A16)
Inconvenience	Legal resource users	"Recreational fishers complain about having to go somewhere else, like someone said, I had to take my daughter to Costa Rica to catch her first swordfish" (P18)
Financial stress	Legal resource users	"It's the stress of uncertainty, of being able to pay debts, send your children to school... One fisher told me that fishers tend to look older than they are, because of the stress they are under" (A17)
Personal time	Legal resource users	"If you spend more time fishing than you usually did, you have less time for parenting… lots of people complain about this" (M13)
Cultural	Legal resource users	"There is a loss of knowledge, of currents and place's names and the behaviour of marine life. You go losing the knowledge and history of a place" (A19) "The fishing industry is the lifeblood of the community" (N1)
Loss of freedom	Legal resource users	"People don't understand why they can't do what they've always done" (W15)
Harassment or social isolation	Legal resource users	"This area used to belong to me but since your area is closed now, you have to come to mind and so I'm going to be hostile to you" (A17)
Increased social inequality	Legal resource users	Women play an important role in collecting clams and other marine resources in the shallow areas. If they lose access to these areas, they become more financially dependent on men. (A17)
Cognitive	Legal resource users	Legal resource users may need to change their type of fishing or learn an alternative livelihood, which requires cognitive input (N2)
Carbon footprint	Society at large	If fishers have to travel further, they may have a higher carbon footprint (A16)

The range of human costs identified by key informants points in (Figs 1a-b, Table 1, Table 2) gives a sense of the social complexity of enforcement and compliance in NTMPAs, and the challenges faced by different groups. However, in the stark categorisation of enforcement and compliance, the meaning of shared costs and ability to switch between roles of legal or illegal resource use and enforcement, as fishers do, is lost. Therefore, the following diagrams (Figs 2a-d) present human costs in four categories: Physical, Material, Psychological and Social. This grouping of costs illustrates that although they are often grouped apart, enforcers and resource users can sometimes face different versions of the same human costs. In these diagrams, arrows

are used to indicate interactions between groups, and colours are used to code whether a group's actions are the result of enforcement, compliance or illegal activity. Italics are used to provide further explanation.

Fig 2a. Physical costs

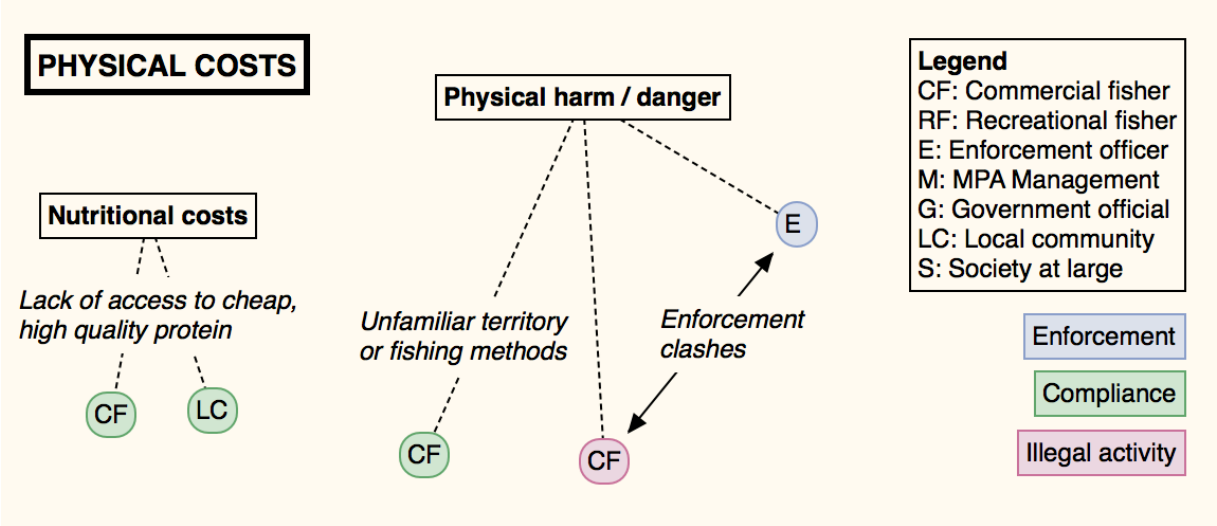


Fig 2b. Material costs

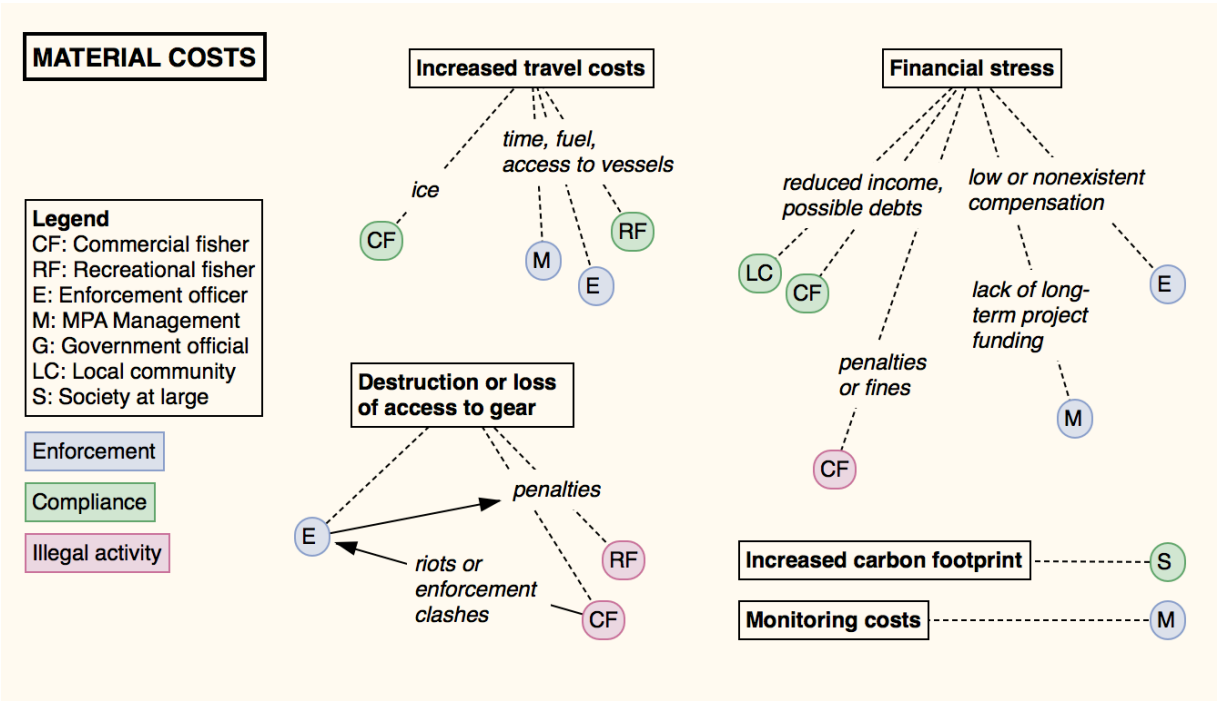


Fig 2c. Psychological costs

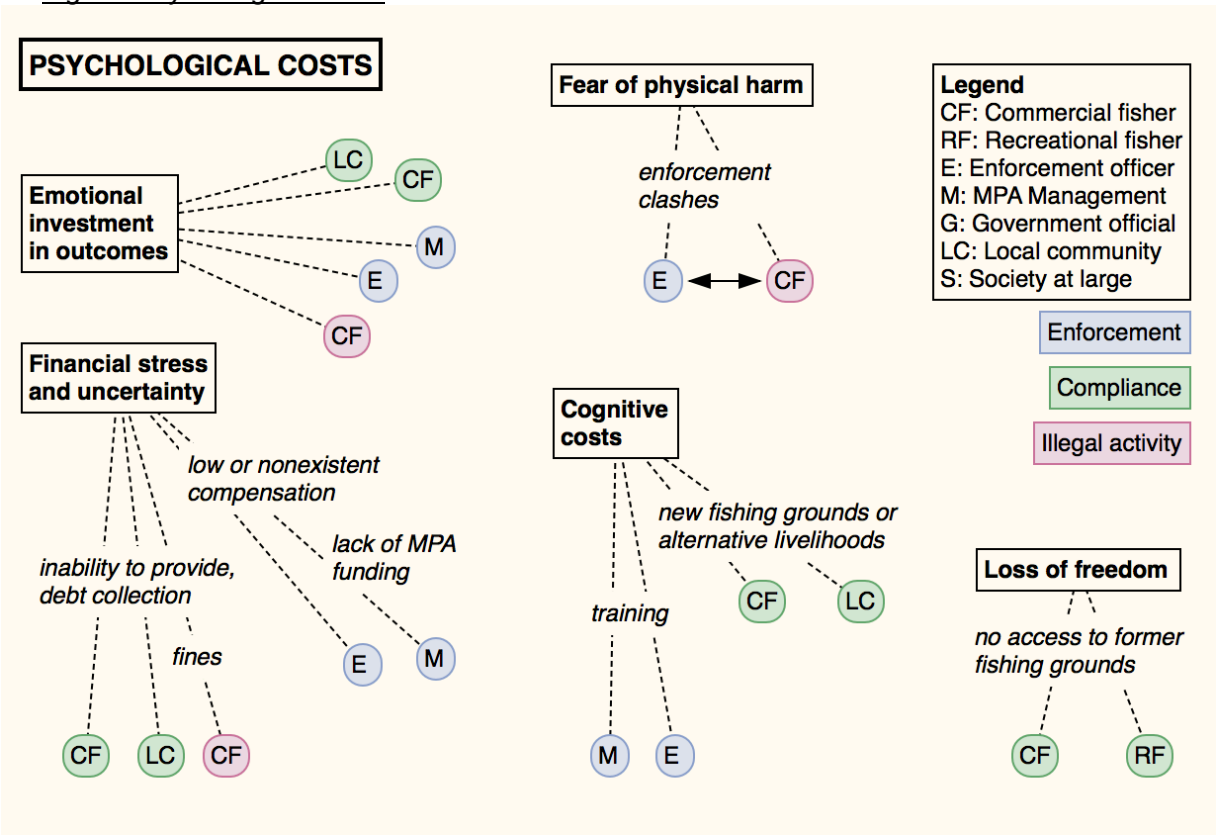
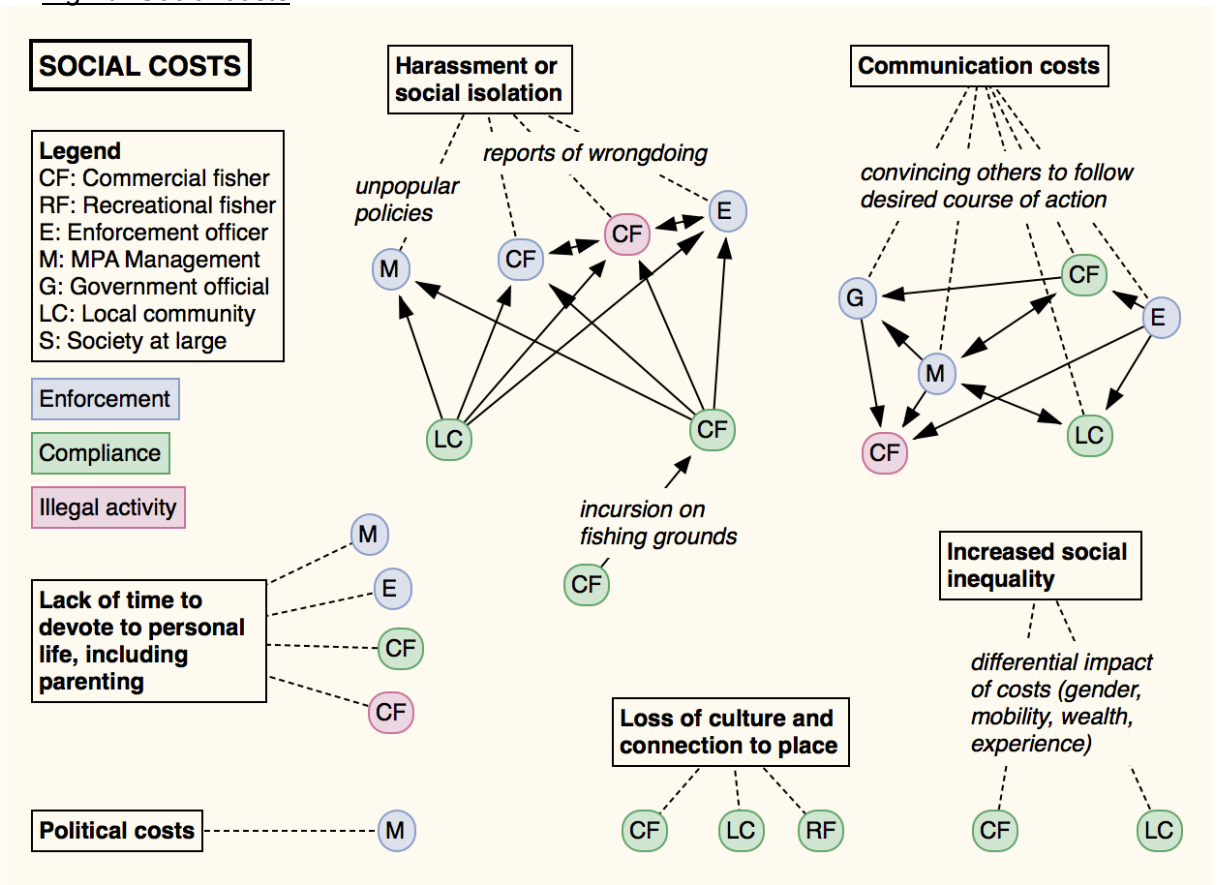


Fig 2d. Social costs



Timing of costs

When assessing the timing of human costs of compliance in NTMPAs, numerous key informants stressed that they believe most human costs are short-term and transitional, as benefits from MPAs begin to accrue for legal resource users within 3-10 years, and costs are consequently balanced out. Estimates for this range of time and the severity of costs depended on several factors, such as the productivity of the ecosystem, the strength of enforcement, involvement of the community in MPA establishment, and the provision of compensation or alternative livelihoods such as seaweed farming and tourism. One NGO practitioner said, ”There are a lot of short term costs to establishing a marine protected area that are generally pretty concentrated… the costs are paid usually by the individuals that are using the area and the people that they have supported” (N5). One MPA manager stated, “the temporality of costs depends on how well you manage the MPA” (M11). Some key informants also suggested compliance and enforcement costs may decrease over time because resource users and local communities adapt to the new situation; as an NGO practitioner noted, “Over time, people either shift their fishing activities or they go into another job, so the costs look different” (N5). However, this practitioner noted that benefits could sometimes be overemphasised in relation to costs, saying, “Benefits are oversold which leads to disappointment and resistance” (N5).

While the majority of key informants believed that human costs of enforcement and compliance would decrease over time if the MPA was managed well and local community members were involved, a few key informants provided points of dissent. One MPA manager suggested that enforcement costs actually go up over time, as increased fish stocks mean that there is more to protect. As fish populations increase, need more enforcement because there are more fish in the area… “the loss we can suffer is much greater” (M11). A couple of key informants stated that human costs of compliance could be semi-permanent, as they did not believe NTMPAs usually solved problems, at least in the case of fisheries; one academic said that in his opinion, a no-take MPA simply stood for “Move problems away” (A16).

Spatial variation of costs

Most key informants agreed that in general, larger MPAs are associated with higher human costs of enforcement and compliance. In terms of compliance, this was generally based on the assumption that an MPA requires resource users to travel further to fish and affects more communities due to its larger spatial extent. As one academic said, “Generally the area is reduced, but the number of fishers is not reduced, so a larger area means greater costs for fishers” (A17). In the case of community-based enforcement or monitoring, one academic pointed out that larger areas could have fewer emotional ties to place, which could decrease the community’s desire to protect an MPA and participate in enforcement: “As an area becomes bigger, you lose capacity of custody, the sense of ownership, of I’m going to defend my territory” (A19). Social enforcement can be effective in small communities near an MPA; as an academic said, “If a community feels ownership, enforcement can be things like coming to shore and their neighbours are upset with them” (A10). On the other hand, some enforcement costs could be increased by proximity to settlements, as it is easier for illegal resource users to make incursions; as an MPA manager said, “There’s a fishing village next to the protected area. It’s easy for people to just get in and get fish and get out” (M14).

Many of these former points can be dismissed if the MPA is not located near human settlements; as one NGO practitioner said, “if an MPA is not located close to people, this is unlikely to be as much of a problem” (N5). Another NGO practitioner echoed this speaking of the MPA establishment process, saying, “There is less pushback to create it if you have less of a human footprint” (N6). However, large and remote NTMPAs can be difficult to enforce because they are almost impossible to monitor completely, and resources are often severely limited. One NGO practitioner gave the example of an MPA in Hawaii, which he stated had only 3 planes and 4 ships to protected 1.4 million square miles (N6). One academic key informant suggested that in these cases, NTMPAs are not the best approach, as regulated fishers can be one of the only ways of keeping “eyes out” to report incursions by unregulated fishers (A16). Costs of enforcement can be higher in larger areas, due to the isolation and enormous distances; one key informant gave the example of a pilot carrying out enforcement in Palau, whose

plane ran out of gas and crashed.

Solutions to costs

After identifying a large variety of costs to numerous stakeholders, key informants were keen to suggest solutions. In the words of one academic, “It’s not simply about protecting it from humans but from detrimental impacts… humans are important partners for restoring these places” (A7, right at end). Suggested solutions generally fell into three categories: open discussion amongst stakeholders during establishment and management of the NTMPA; use of technology, training, and clear communication and regulations in enforcement; and the mitigation of costs for local resource users.

1. Transparent discussion of problems during establishment and management of NTMPA

Various key informants highlighted the role of discussion and inclusion in alleviating conflict. As one NGO practitioner said, “Often people see conflict as a thing that needs to be avoided, but the existence of a conflict can be a launching-off point for a conversation… it’s possible to use that conflict to come together” (N5). In addition to the consultation periods that ideally occur when an MPA is being established, this means a continuous feedback of information during MPA management. One manager gave the example of the MPA he works at, where Tuesday nights are used as an open feedback mechanism for fishers, which he admits can turn into “complaints nights” but also allows for communication about issues as they arise (M11). The use of physical spaces in this example was particularly interesting, as the manager gave the example of his office being located on the beach where fishers spend time, so they can come in at any time, and contrasted it with the offices of another MPA, which are located in a hotel that requires fishers to go through security and walk past tourists if they want to speak to the MPA managers, resulting in reduced feedback. Another NGO representative suggested another way to reduce antagonism identified by the Zoological Society of London is shared use of infrastructure, such as guard huts being used as a base for enforcement but also for drying seaweed (N2). A former warden agreed with the need for

communication across groups, saying, “Somewhere, you have to find the common ground, so that people feel that they are included, but they are included to resolve something. Not included just to have their own way, but involved in the process of making good decisions” (R12). A number of key informants indicated the importance of adaptive management, which can sometimes be identified by a large number of infractions, and of constantly communicating findings with the local community, which one manager said “makes a statement that the management body is functional and serious” (40 mins).

Engagement of people likely to be affected by a NTMPA early on in the establishment process was identified as a critical way of reducing human costs, and one NGO practitioner stated, “Every cost should be included in the MPA design process so people don’t feel ostracised or marginalised” (N6). In some cases, key informants cautioned, this could mean not establishing the MPA in the first place, or adjusting goals according to the human costs that will be placed upon the community. Several key informants warned against the establishment of very large MPAS with “no hope of enforcement” or effective management, as this can lead to significant social conflict and a lack of effectiveness. Two key informants also strongly advocated against the creation of NTMPAs when indigenous groups are opposed, as their uses developed over thousands of years can often be sustainable and based in important cultural traditions. As intermediate mechanisms when management is feasible and local community members are amenable, key informants suggested collaboration in choosing areas to be closed off, or closing off smaller areas, as ways to include the community, increase buy-in, and reduce impacts (A3, N5, A7, A8). The initial stage was identified as particularly important by an NGO practitioner because it sets the stage for further interactions, saying, “In practice, if an MPA is established and people are upset, it’s difficult to get people on board” (N5). Various key informants stressed the importance of going into these interactions with transparency, openness and respect, rather than as a “box-checking exercise” which local people will recognise and resent (A10). This is particularly important when the group establishing the MPA is not local, and when dealing with indigenous peoples. Various key informants stated the importance of reconceptualising marine enforcement and governance, which multiple key informants

described as the “Wild West.”

2. Use of technology, training, and clear communication and regulations in enforcement

The role of technology in reducing the costs of MPA enforcement was highly charged with key informants. Many thought technology could be useful in enforcing NTMPAs with limited resources, by increasing the scale of monitoring and enabling detection of wrongdoing. Forms of technology suggested included drones, transponders, and the use of risk-based analysis to plan enforcement (M13, A16, N6). As an MPA manager said, “You can’t be in two places at once, but with CCTV, you can” (M11). However, there was also recognition that technology is not a panacea; as an NGO practitioner said, “technology is a tool, not a solution” (N4). Key informants with experience of enforcement unequivocally said physical presence of enforcers was necessary to carry out enforcement successfully. A couple of key informants pointed out that technology is also used by illegal resource users to avoid detection, as they can be tipped off about enforcement routes via mobile phone or radio. One academic gave an example, of enforcement officers going out to patrol on a day when radio signal went down, and catching numerous fishers who had not been forewarned.

Key informants with experience of practical MPA enforcement highlighted the need for more extensive training for MPA wardens, saying many are untrained, though they carry out the day-to-day work of enforcement. One academic suggested that a specialised police force for marine affairs would be helpful, as many enforcement agents are trained in terrestrial enforcement. An NGO practitioner summarised this saying, “I don’t think weapons and arms are the answer. I think it’s more training” (N6). Another NGO practitioner suggested that responsibilities of an enforcer be reframed, saying an enforcement agent “needs to be an ambassador and a communicator, almost more so than an enforcer” (N4). Training in ethics and avoidance of escalation during enforcement interactions was identified as key, with the same NGO practitioner saying, “It has a huge impact with a potential perpetrator, how they approach. It’s important in

terms of the tone they speak" (N4).

Communication and education were identified as a critical element in NTMPA enforcement and compliance, as one academic suggested that many infractions occur due to "ignorance as opposed to maliciousness" (A16). One manager stated, "When we did awareness, a lot of poaching reduced" (M14). Due to the social difficulties of carrying out enforcement in a small community, one academic suggested the use of enforcement agents that rotate every two years so that they would not "go native" (A7) though an NGO practitioner suggested this approach could be problematic because external wardens would not understand the effects of enforcement on the local community (N1). One former warden suggested the use of "junior ranger" programmes with local children as young as 9 years old, to foster appreciation for the ocean and a culture of compliance. One NGO practitioner suggested using models of redemption rather than punishment, as he had witnessed in Madagascar, where illegal resource users who have been caught have to buy a cow for a village feast, creating a benefit for the community (N2). He also suggested the creation of positive incentives to motivate local communities, such as a yearly competition that exists in the Philippines for the most effective MPA (N2).

A former warden emphasised the importance of clear and enforceable phrasing in MPA regulations. As an example, this former warden explained that it is very difficult to catch someone in the act of spear fishing because they are underwater, and so suggested a prohibition on the possession of spear guns in a NTMPA, rather than the act itself. An academic echoed the need for clarity with MPA boundaries out on the sea, and the use of landmarks that fishers can recognise (A16). A former warden advocated that wardens should have the ability to stop and search vessels, as the inability to do so can hinder enforcement and the collection of evidence. An NGO practitioner suggested the use of checklists, widespread dissemination of regulations and slowly ramping up enforcement at first using warnings, saying "You don't flip the switch from 0 to 100" (N4). Key informants with experience of enforcement stated the importance of completing the chain of enforcement, from detection to punishment, but cited problems of corruption and bureaucratic inefficiency. Finally, several key informants including a

former warden said that enforcement agents should be compensated fairly for their work, as they are often paid very low wages and this could be an incentive, reducing problems of corruption and the expense of retraining.

3. Mitigate costs for resource users (Alternative livelihoods, offsetting of existing costs, compensation, preferential user rights, etc)

Numerous key informants discussed the importance of decreasing human costs of compliance for resource users, in order to ensure the effectiveness of an MPA and allow benefits to materialise if conditions are right. Alternative livelihoods such as seaweed farming and tourism were suggested, with the caveat that access to markets is key. One academic suggested that a diversity of realistic alternative livelihoods is important, because “If you’ve got an entire community that is dependent on access to fish stocks, they are not all going to make a living out of coconut wine or rattan mats” (A3). Though tourism has been successful in numerous cases worldwide, an NGO practitioner noted that conditions need to be appropriate and there are many important ecosystems that would not necessarily draw crowds, saying, “You need MPAs everywhere but you can’t have tourism everywhere” (N2). Another NGO practitioner suggested that fishers could be paid and trained to work as wardens, saying “they are the most passionate because they want to see fisheries recover” (N1).

Another key informant suggested finding ways to offset existing costs for fishers, such as the cost of making ice by establishing solar power units, or access to markets by linking them to premium suppliers (N1). Another option for raising revenue was for community members to put money into a collective pot, which can then be used as leverage to get more money for enforcement (N2). One academic noted that this is often the only option for some scall-scale fisheries in developing countries, and that is has been successful in regenerating fisheries for local communities in situations where it is possible to exclude illegal resource users (A19). A final option that was suggested was to establish preferential user rights for compliant local resource users, so that they have an incentive to protect and respect the NTMPA (M13). Other ways of materialising benefits for local resource users can be to generate revenue by charging for tourist

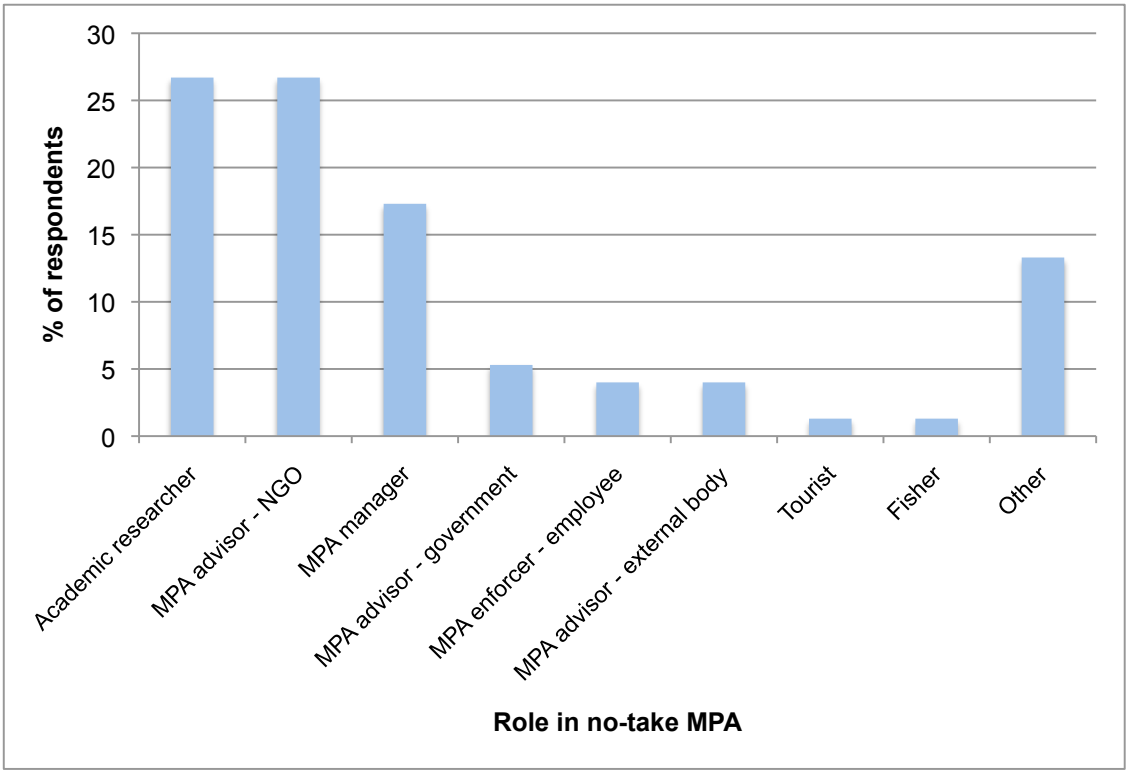
entry in no-take areas, and using these fees to build infrastructure for the community, such as hospitals and clinics (M14).

Results: Online survey

Breakdown of survey respondents and MPA characteristics

Respondents to the online survey had a range of roles in NTMPAs (Fig 3A), and were mostly academic researchers (27%), MPA advisors (27% NGO-based, 5% government based, and 4% based at an external body such as the World Bank) and MPA managers (17%), with fewer enforcement employees (4%) and only one fisher (1%) responding to the survey. The majority (67%) of respondents reported that they had 3 or more years of experience with the MPA in question.

Fig 3a. Respondent role in NTMPA (Online survey, n=75)



Respondents reported on MPAs with a range of ages and management times, sizes, and purposes, from a total of 34 countries. The majority of MPAs were 100% no-take, though some contained smaller no-take zones within the MPA. The majority of survey respondents indicated that biodiversity conservation (84%) or fisheries management (45%) had been a particular purpose for the MPA's establishment (Fig 3b). Most MPAs

had been established (87%) and actively managed (79%) for 6 years or longer. Finally, when asked to identify the primary group responsible for establishing and managing for the MPA, many of the MPAs reported were established (31%) and managed (32%) by national government, followed by local government and then local communities. MPAs also covered a range of sizes, from under 5 sq km to over 10,000 sq km (Fig 3c).

Fig 3b. MPA establishment purpose (Online survey, n=75)

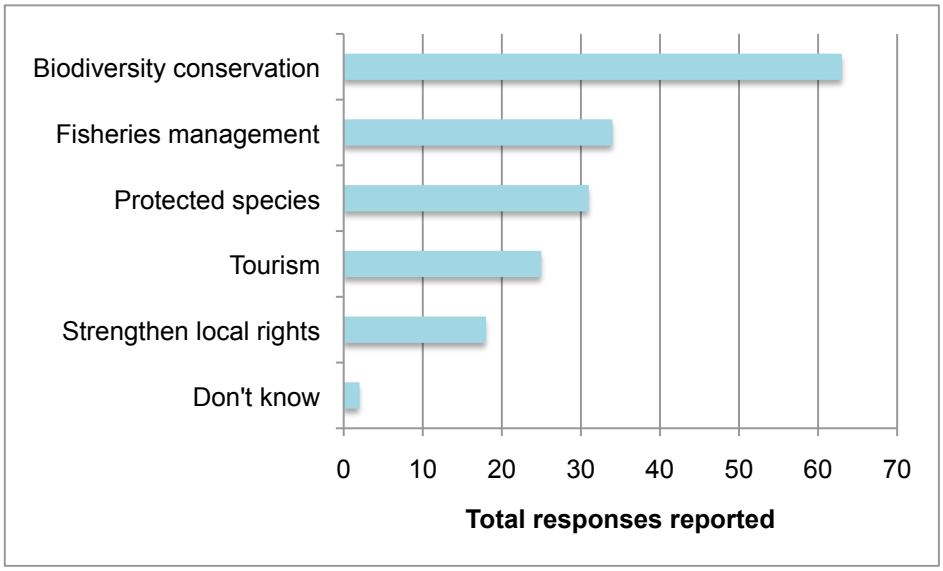
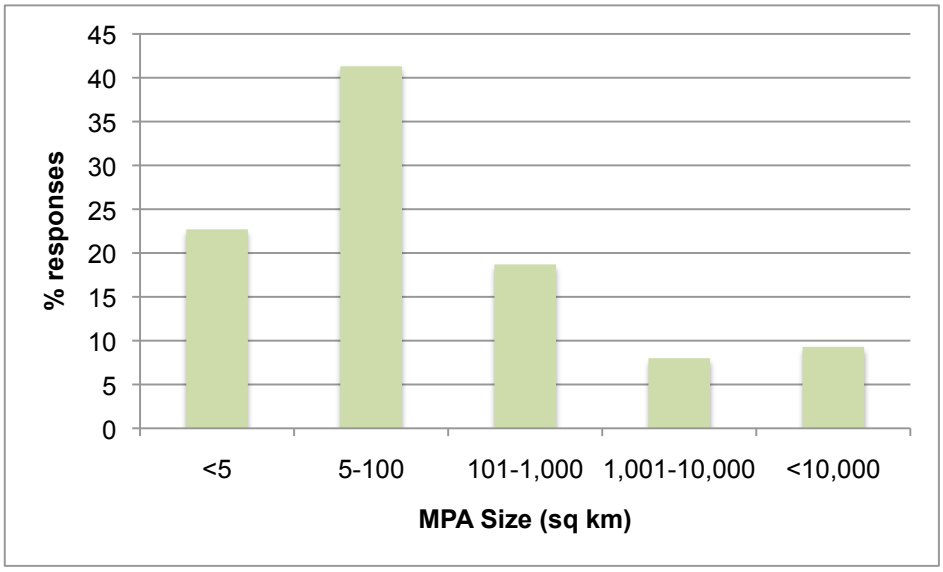


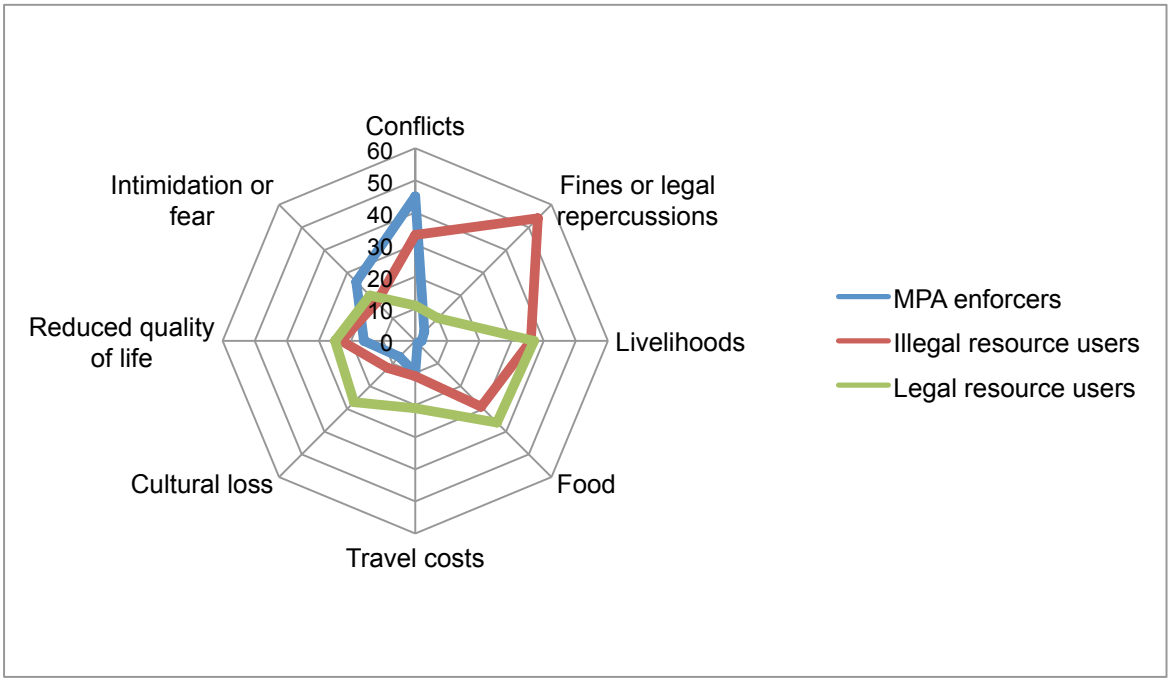
Fig 3c. MPA size (Online survey, n=75)



Data on human costs of enforcement & compliance

Online survey respondents reported the occurrence of various human costs at their MPAs, affecting MPA enforcers and illegal and legal resource users. The following graph shows the spread of human costs reported, with numbers on the central axes corresponding to the number of responses indicating the presence of each cost in the respondent's MPA. It complements the graphs and tables presented for the key informant interviews, though the categories are not identical as the survey was sent out prior to the conclusion of the interviews. The "conflicts" category can be seen as an amalgamation of harassment and physical danger from enforcement clashes. Reports for conflict indicate similar results to the key informant interviews, as MPA enforcers and illegal resource users are most affected, and legal and illegal resource users are most impacted by livelihood costs and food costs. The fact that legal resource users were identified as most impacted by cultural loss and travel costs also aligns with the results of the key informant interviews. It is notable that fear was reported more for MPA enforcers than illegal resource users, though this may reflect a bias in the survey towards MPA management and enforcers rather than resource users.

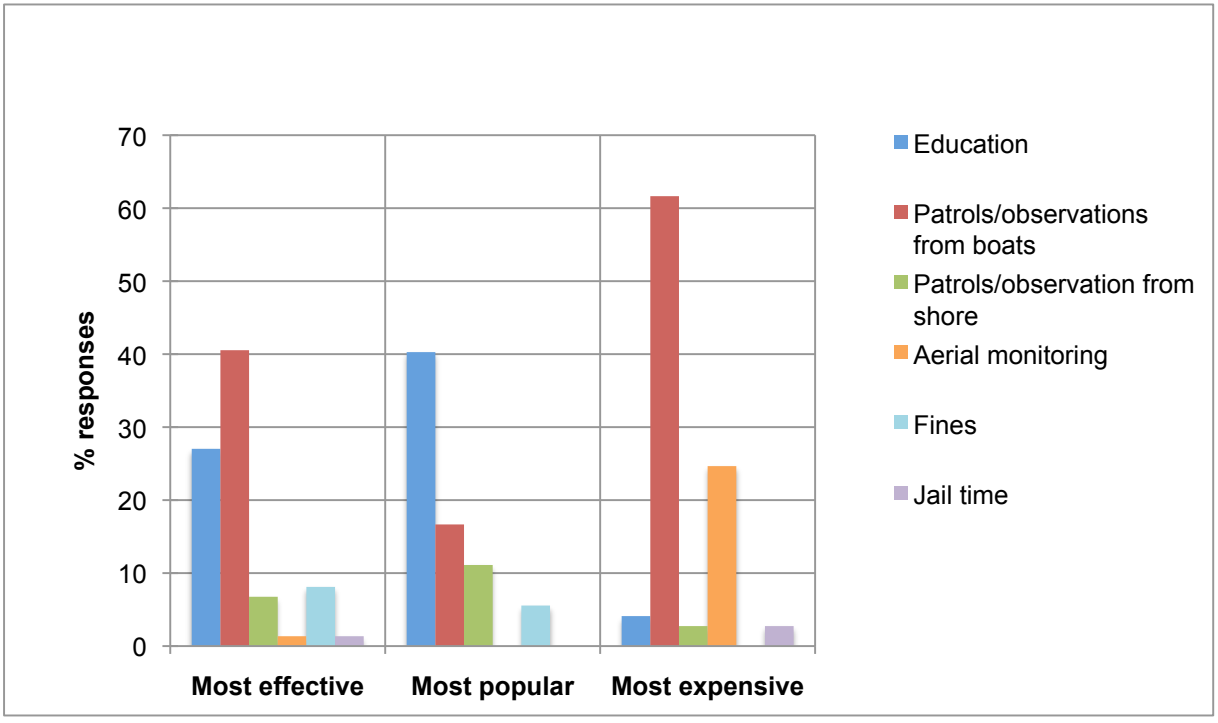
Fig 4. Human costs of enforcement and compliance by group (online survey, n=75)



Responses indicated that enforcers and legal and illegal resource users are subject to different costs of MPA enforcement and compliance, with illegal resource users most affected by fines or legal repercussions, MPA enforcers most affected by conflicts and intimidation or fear, and legal resource users most affected by a lack of food, travel costs and cultural loss.

In order to gain a quantitative understanding of optimal enforcement methods, respondents were asked to rank different methods of enforcement based on expense, popularity and effectiveness. Methods of enforcement included both "soft" and "hard" enforcement measures. The following graph shows the spread of enforcement methods, based on effectiveness, popularity and expense.

Fig 5. Effectiveness, popularity and expense of enforcement methods in NTMPAs (Online survey, n=75)



Responses to this question are relevant to the solutions to human costs suggested by key informants, particularly methods of enforcement including technology. Online survey data indicated that patrols and observations from boats – the most traditional method of marine enforcement, known as "boots on deck" – is considered by survey respondents to be both the most expensive and effective. Education, another traditional

method of enforcement, was ranked as inexpensive but popular and effective. Aerial monitoring was ranked as expensive by many survey respondents, but neither as popular nor effective.

DISCUSSION

The results of the key informant interviews and online survey conducted for this project reveal a great range of human costs affecting a number of stakeholder groups involved in NTMPA enforcement and compliance. I believe this supports the idea that social complexity of NTMPA enforcement in particular has not been fully recognised, and that human costs deserve greater attention in research and in the practical establishment and management of NTMPAs. One key informant, an NGO practitioner, agreed with this statement saying, “Everyone understands the benefits… We need to find ways to overcome the costs of no-take zones” (N2). Results are relevant to the management of protected areas in general, as many of the dynamics that occur between enforcers and resource users in MPAs also occur in terrestrial protected areas.

I found it particularly interesting to see that although legal and illegal resource users, MPA managers and wardens are often conceived of as very different groups with different motivations, in various cases the different groups seem to be suffering different versions of the same human costs. This applies to financial and time stress, fear of social isolation and physical harm, and the cognitive and communication costs of attempting to learn new things and communicate with different groups. This serves as a reminder that even as people carry out professional functions making an MPA effective or adapting to its impacts on their livelihood, at the root level, humans are impacted by similar stresses in relation to setting and abiding by restrictions on their activities.

Identification of costs

The wide variety of costs identified by key informants is consistent with Pollnac et al's (2010) assertion that high levels of compliance in NTMPAs are closely associated with complex social processes, and underscores the need to understand these social processes. Suggestions given by former warden key informants about the need to clarify regulations and disseminate them widely, as well as some NGO and academic key informants regarding the importance of outreach during the MPA establishment process, support Christie et al (2006)’s conviction that transparency and understanding

in MPA processes are key to supporting compliance and the reduction of conflict. Similarly, several key informants discussed the idea expressed in Rogerson et al (2015) that conservationists and fishers have fundamentally different world-views, and may understand marine spaces in completely different ways.

Many of the costs of compliance identified in this survey were closely linked to those that have been documented in the literature by Cinner et al (2014) and others, with the exception of time lost for parenting and the loss of freedom. When it comes to nutritional costs, the work of Aswani et al (2007) on the health and nutritional impacts of NTMPAs suggests that in fact, effectively managed NTMPAs can provide greater food security in the long run, and are unlikely to succeed if any kind of nutritional costs are imposed on resource users. This concurs with key informant comments about resource users always finding ways to fish if they are faced with hunger. However, the costs of enforcement, particularly harassment and social isolation in management and for wardens, appear to have received little prior attention in the academic literature. The role of resource users who also act as enforcers was particularly interesting, as they may be facing costs on both sides.

When it comes to reported social costs, results of this study relate to Basurto et al (2016)'s work demonstrating the heightening of prosocial and antisocial interactions between compliant resource users in places where MPAs are established. The human costs identified in this study relating to social interactions, such as harassment, may also increase in NTMPAs. In relation to Balmford et al's (2004) study about financial costs for MPAs, which found a reduction of financial costs as MPAs are placed further from inhabited areas, may also apply for human costs as well as the "human footprint" will be lower in more remote MPAs. As the online survey did not include questions about proximity to settlement, I suggest a quantitative analysis of this information in future.

Methods & stages of enforcement

When it comes to particular methods of enforcement, the importance of education

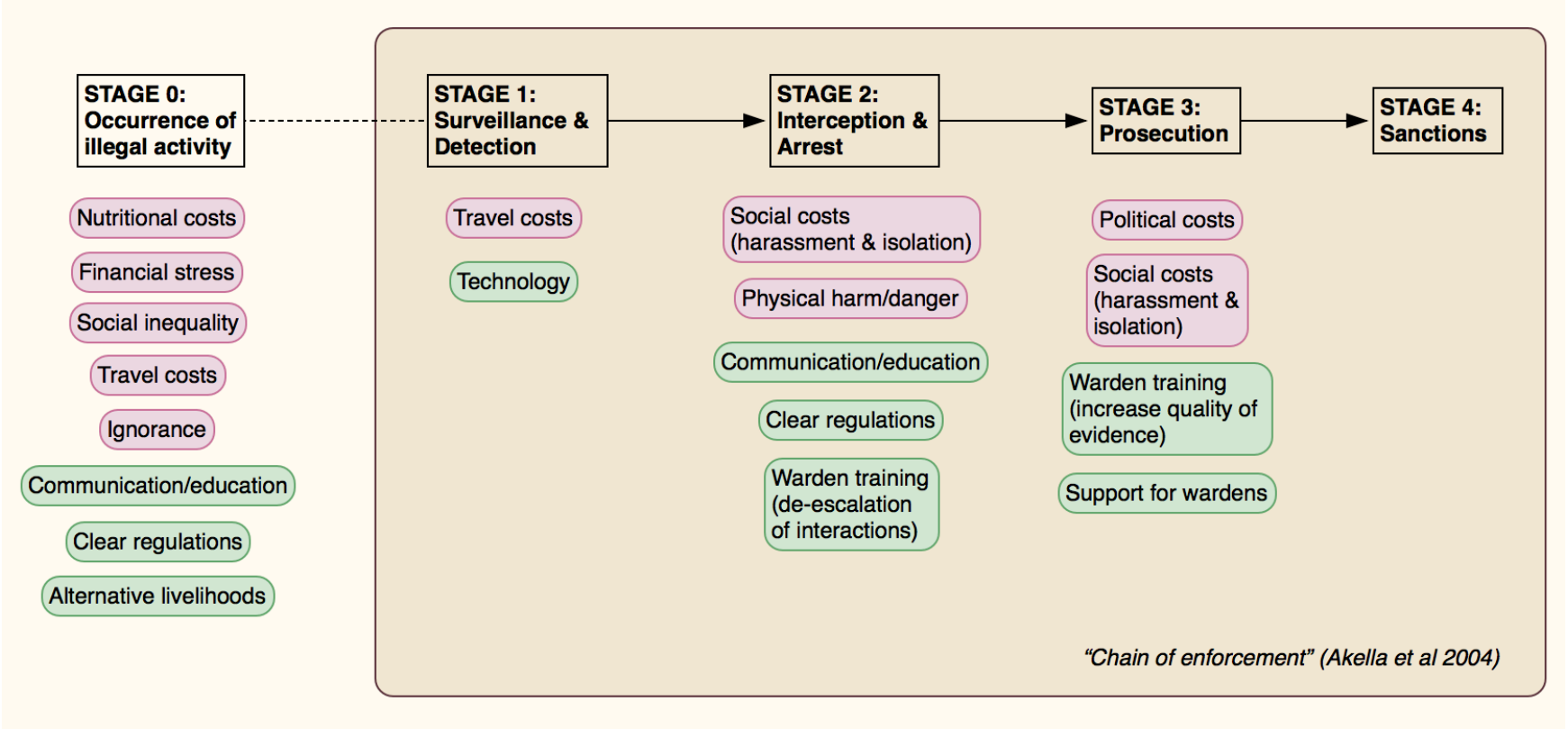
emphasised by Sáenz-Arroyo et al (2005) was highly supported both by key informants, including one MPA manager who explicitly stated compliance went up following awareness efforts, and by results from the online survey, which identified education as an effective, inexpensive and popular method for enforcement. López-Ornat et al's (2015) categorisation of boat patrols as prohibitively expensive was similarly supported by the online survey results, which identified boat patrols as the most expensive method of enforcement, but also the most effective, suggesting that cost-benefit ratios should be more deeply explored for different enforcement methods. López-Ornat et al (2015)'s suggestion for land-based patrols as an alternative was not supported by the online survey, as respondents did not identify land-based patrols as effective. However, if land-based patrols increase positive non-aggressive social contact between enforcers and resource users they could lead to a different type of success, as many key informants identified social contact as a way to reduce conflict and increase compliance through communication. If this contact was aggressive, it might simply perpetuate further human costs. López-Ornat et al (2015)'s suggestions about the importance of management providing support for enforcement agents are highly supported by the results of this study, as key informant interviews and online survey data evidenced a number of human costs for enforcement agents. The idea of using surprise patrols could be successful according to key informants, particularly given the story of catching illegal resource users on a day when radio signal went down.

In relation to the work conducted on the role of legitimacy in fostering voluntary compliance, by Ostrom (1998) and Stern (2008), results of this study suggest that cognitive and communication costs, both on the part of managers to explain reasoning for NTMPAs, and on the part of resource users to participate in NTMPA establishment and management, though time consuming, may be one of the greatest investments that could be made in NTMPA effectiveness.

As can be seen in Fig 6 on the next page, the incorporation of human costs into Akella et al (2004) and Rosero et al (2010)'s analyses of the stages of enforcement may provide a useful tool for mapping human interactions in the enforcement process. In particular, travel costs seem to apply to the first stage of "Detection," and MPA

managers supported the assertion that technology could be helpful in this stage. Financial strain, social isolation and harassment for MPA wardens and managers seem key to the second stage of “Arrest,” and their suggestion for further training and fair pay for wardens, as well as clear regulations, was resoundingly supported by former wardens as well as MPA managers. Political costs apply to Stage 3, “Prosecution,” though key informants did not provide any solutions for this problem. In general, Akella et al (2004)’s call for more data collection around enforcement is strongly supported by the results of this study.

Fig 6. Mapping human costs of enforcement & compliance onto the "Chain of enforcement"



Critical evaluation of study

Key informant interviews were conducted with people who had a variety of experiences about NTMPA enforcement and compliance; however, it would have been ideal to speak to more fishers, particularly ones who would be willing to discuss the costs of having engaged in illegal activities, and current MPA wardens. Many of these people do not have a publicly identified presence, so given the limited time for the study and that many interviews were conducted remotely, I believe it would be necessary to do a study on a specific area and conduct those interviews in person. In a similar vein, this study provides a list of potential costs identified worldwide, which may or may not apply to specific MPAs. In order to understand how individual human costs apply to MPA governance and management in context, and apply them to enforcement processes, it would be necessary to have knowledge of specific MPAs or carry out future studies and fieldwork in person.

The use of an online survey, and non-probability based sampling, means that responses are biased to people with access to the internet, who are probably wealthier and have more education than the average person suffering costs from enforcement and compliance in a NTMPA, and likely to have some involvement in the conservation community. Therefore, if possible, further investigation with a randomly selected sample of people associated with NTMPAs would help to elucidate the role of human costs on enforcement and compliance in NTMPAs. The sampling for a study like this would be challenging, however, given the logistical constraints of in-person sampling.

Also regarding the online survey, I am aware that it would be possible to carry out statistical analyses of factors associated with the different human costs reported by respondents. Time constraints prevented me from doing this, but I plan to carry out this analysis post-MSc, using a generalised linear model of the probability of a cost being reported as a function of the respondent's role, MPA age, MPA size and type and the group affected by the cost. I also hope to

increase the size and diversity of the sample, so that it is as representative as possible of the global range of NTMPAs.

CONCLUSION

The wide variety of physical, material, psychological and social human costs of enforcement & compliance identified in this study are highly relevant to the establishment and management of NTMPAs. The resulting typology of costs and suggested solutions may be useful in framing discussions around the appropriateness of establishing NTMPAs in a given site, as well as guiding stakeholder discussions around adaptive management. The identification of these human costs reaffirms the importance of managers and enforcers interacting with local communities and resource users, the reduction of conflict and likelihood of physical harm during enforcement interactions, and the direction of appropriate levels of training and funding towards NTMPA management, including programmes that mitigate loss of livelihood for compliant resource users. The importance of social interactions, including human costs, cannot be underestimated in managing enforcement and compliance and ultimately creating ecological effectiveness. This is particularly true because costs are often more immediate and may play a larger role in determining stakeholder behaviour than benefits that are perceived as distant. The investment of time and cognitive effort in communication around compliance and enforcement, by enforcers and legal and illegal resource users, plays an important role in establishing and managing effective MPAs. Further investigation is needed to assess the prevalence and severity of these human costs across economic, geographical and governance divides for NTMPAs.

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RESEARCH PROJECT PARTICIPATION

Online Survey Information Sheet

Study Title: Human costs of compliance and enforcement in Marine Protected Areas (MPAs)

CUREC Ethics Reference: SOGE 1A-89

Background and aims of the study: The aims of this project are to assess the prevalence and impact of human costs of enforcing and complying with MPAs, which includes costs both to the MPA staff and to resource users associated with the MPA. We recognise the substantial ecological and social benefits of MPAs, but feel that the costs of MPA enforcement (and how to mitigate them) are less well researched. Therefore we hope to answer questions of how prevalent human costs are, how, when and where they occur, and how they could be mitigated. The project is being conducted as a dissertation project for the MSc course in Biodiversity, Conservation & Management at the University of Oxford.

Why have I been invited to take part? You have been invited to take part because you have insights about, or experience of, enforcement of Marine Protected Areas.

Do I have to take part? You can ask questions about the study before deciding whether to participate. It is your decision whether to participate in this study, and if you agree to, you may withdraw yourself and any data associated with you from the study without penalty at any time, and without giving a reason, by advising researchers of your decision.

What will happen in the study? You will fill anonymously fill out the online survey on this page, and results will be analysed as part of the MSc project.

Are there any potential risks in taking part? Filling out the survey may be distressing to some participants as it covers the risks and dangers of enforcing Marine Protected Areas. The survey will be anonymous, so data will not be linked to individuals unless they choose to provide their contact information at the end of the form.

What happens to the research data provided? Research data will be analysed to assess the prevalence and impacts of human costs of enforcing Marine Protected Areas, and to identify possible strategies for mitigation.

Will the research be published? The University of Oxford is committed to the dissemination of its research for the benefit of society and the economy and, in support of this commitment, has established an online archive of research materials. This archive includes digital copies of student theses successfully submitted as part of a University of Oxford postgraduate degree programme. Holding the archive online gives easy access for researchers to the full text of freely available theses, thereby increasing the likely impact and use of that research.

If you agree to participate in this project, the research will be written up as a thesis. On successful submission of the thesis, it will be deposited both in print and online in the University archives, to facilitate its use in future research. The thesis will be published with open access. It may also be reworked and submitted for publication in a peer-reviewed journal, and results may appear in blogs or the wider press.

Who has reviewed this project? This project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee. It has also been reviewed by the project supervisor, Professor EJ Milner-Gulland. Participants who provide contact details will receive information about the project when it is complete. Results will be published online in the form of an MSc thesis, and may be published in a peer-reviewed journal.

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Chair, **Social Sciences & Humanities Inter-Divisional Research Ethics Committee**
Email: ethics@socsci.ox.ac.uk
Address: Research Services, University of Oxford, Wellington Square, Oxford OX1 2JD

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RESEARCH PROJECT PARTICIPATION

Online Survey Information Sheet

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RESEARCH PROJECT PARTICIPATION

Key Informant Interview Information Sheet

Study Title: Human costs of compliance and enforcement in no-take Marine Protected Areas (MPAs)

CUREC Ethics Reference: SOGE 1A-89

Background and aims of the study: The aims of this project are to assess the prevalence and impact of human costs of enforcing and complying with MPAs, which includes costs both to the MPA staff and to resource users associated with the MPA. We recognise the substantial ecological and social benefits of MPAs, but feel that the costs of MPA enforcement (and how to mitigate them) are less well researched. Therefore we hope to answer questions of how prevalent human costs are, how, when and where they occur, and how they could be mitigated. The project is being conducted as a dissertation project for the MSc course in Biodiversity, Conservation & Management at the University of Oxford.

Why have I been invited to take part? You have been invited to take part because you have been identified as an expert in Marine Protected Area management.

Do I have to take part? You can ask questions about the study before deciding whether to participate. It is your decision whether to participate in this study, and if you agree to, you may withdraw yourself and any data associated with you from the study without penalty at any time, and without giving a reason, by advising researchers of your decision.

What will happen in the study? Once you have given your consent to participate in the study, I will conduct an interview with you, either in person, on the phone or on Skype. The interview will last approximately 30 minutes.

Are there any potential risks in taking part? Interviews could be distressing to some participants as they cover risks and dangers of enforcing Marine Protected Areas. Interviews may be abandoned or re-scheduled at any time if this is the case.

What happens to the research data provided? Research data and quotes will not be linked to individuals. Generic, non-identifying, information may be attached to quotes in order to provide context. The information you provide will also be used to inform the structure of an online survey as well as to understand the overall nature of the problem. You may choose to be acknowledged by name in the acknowledgements section of the thesis.

Will the research be published? The University of Oxford is committed to the dissemination of its research for the benefit of society and the economy and, in support of this commitment, has established an online archive of research materials. This archive includes digital copies of student theses successfully submitted as part of a University of Oxford postgraduate degree programme.

Holding the archive online gives easy access for researchers to the full text of freely available theses, thereby increasing the likely impact and use of that research.

If you agree to participate in this project, the research will be written up as a thesis. On successful submission of the thesis, it will be deposited both in print and online in the University archives, to facilitate its use in future research. The thesis will be published with open access. It may also be reworked and submitted for publication in a peer-reviewed journal, and results may appear on blogs or in the wider press.

Who has reviewed this project? This project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee. It has also been reviewed by the project supervisor, Professor EJ Milner-Gulland. Participants who provide contact details will receive information about the project when it is complete. Results will be published online in the form of an MSc thesis, and may be published in a peer-reviewed journal.

Who do I contact if I have a concern about the study or I wish to complain?

to the ***relevant researcher,*** [redacted] The researcher should indication of how she intends to deal with it. If you remain unhappy or wish to make a formal complaint, please contact the chair of the Research Ethics Committee at the University of Oxford (using the contact details below) who will seek to resolve the matter in a reasonably expeditious manner:

Chair, **Social Sciences & Humanities Inter-Divisional Research Ethics Committee**
Email: ethics@socsci.ox.ac.uk
Address: Research Services, University of Oxford, Wellington Square, Oxford OX1 2JD

Key Informant Interview Script

Hello, I am [redacted] from the University of Oxford, and I wanted to talk to you about the project I contacted you about before. To recap, the broad aims of my project are to assess the different types of human costs of enforcing and complying with no-take Marine Protected Areas, how widespread they are, what impact they have on people and nature, and how to mitigate these costs. I hope that this research will help to inform the management and design of MPAs in the future.

I wanted to speak to you in order to gather information, insights and expert advice about the issue. This information will be used to improve my understanding of this complex issue, and may be used to structure my online questionnaire. I may use quotes from your interview in my dissertation, but these will not be attributed to you, and will not be traceable back to you.

Are you interested in taking part in the project? … That's great. I just wanted to go over again some of the details of the project to make sure you understand what's involved for you. These were that:

- It's a project about human costs of enforcement and compliance in no-take Marine Protected Areas worldwide, and it is being used for my MSc dissertation.
- If you take part, I'll need you to do a 30-minute interview with me, either on the phone, on Skype or in person.
- This interview may be uncomfortable, as I'll be asking about your experiences with and opinions on the costs of enforcing Marine Protected Areas.
- You don't have to say yes to the project; you can ask me any questions you want before or throughout; you can also withdraw at any stage.
- You know that Oxford University's Ethics committee has approved this work
- I won't use your name next to data you provide
- I will audio record you, unless you object.
- You're aware that my written work will be published online

Are you still willing to take part? … So if you're happy with all of that, and have no more questions, let's start.

Questions

1. Let's start quickly by clarifying what we mean by the human costs and benefits of no-take zones in MPA enforcement and compliance. My premise is that in order for MPAs to be effective at their mission of conserving marine biodiversity and building sustainable fisheries, the rules set out for them need to be adhered to. No-take zones are one clear

example of those rules, where no resources can be extracted from the MPA. Enforcement refers to the management processes and tactics undertaken to ensure that rules are adhered to, and compliance refers to the choices made by resource users to adhere to these rules. An effective MPA can have benefits to local, national and global society as well as potentially to local fishers, tour operators, MPA staff and others. But it will also have costs to a range of different people. And the range and complexity of these costs is currently less well understood and appreciated than the benefits. Do you think that this is a fair representation of the facts?

2. Who do you think could suffer costs from MPA enforcement and compliance in no-take zones? Can we list the main groups of people who suffer cost? How do these groups relate to the groups who benefit from an effectively managed no-take zone in an MPA?
3. What are the different types of cost that these people may suffer? Are they short or long term, chronic or acute, material, social or psychological? Can we produce a diagram together which lists these different types of cost to different people?
4. Time: At what points in MPA management do you think these costs bite, and at what points do the benefits kick in? Are these costs and benefits felt over days, weeks, years, decades? Can you recount any examples from your own experience?
5. Space: How do you think that costs of no-take zone MPA enforcement and compliance vary in scale, from local to global? Can you recount any examples from your own experience?
6. Certainty: Some costs are risks (e.g. the risk of being caught in a no-take zone or of being injured by a poacher as a law enforcement official). Other costs are more certain (e.g. the cost of not being able to access fishing grounds any more). How do you think these different kinds of cost compare? Which are more common, which more important, in your experience? Are they different in the way they affect people? Do you have any examples of this you can share with me, from your experience?
7. To what extent do you think the costs of MPA enforcement and compliance (or “adherence to MPA rules”) actually cause a problem for effective management, based on your own experience? Do you think the extent to which costs may compromise the goal of MPAs varies worldwide and by type of MPA?
8. Can you recount any examples from your own experience of where the costs enforcing or complying with MPAs have impacted the effectiveness of an MPA?
9. What solutions do you see to reduce the most important costs of MPA enforcement, based on your own experience?
10. Do you have any other thoughts or points that we have not covered?

Thank you very much for your time.