


# Closing the compliance gap in marine protected areas with human behavioural sciences

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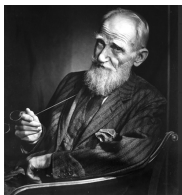
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## Abstract

Advocates, practitioners and policy-makers continue to use and advocate for marine protected areas (MPAs) to meet global ocean protection targets. Yet many of the worlds MPAs, and especially no-take MPAs, are plagued by poaching and ineffective governance. Using a global dataset on coral reefs as an example, we quantify the potential ecological gains of governing MPAs to increase compliance, which we call the 'compliance gap'. Using ecological simulations based on model posteriors of joint Bayesian hierarchical models, we demonstrate how increased compliance in no-take MPAs could nearly double target fish biomass (91% increases in median fish biomass), and result in a 292% higher likelihood of encountering top predators. Achieving these gains and closing the compliance gap necessitates a substantial shift in approach and practice to go beyond optimizing enforcement, and towards governing for compliance. This



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## Etymology of Ghoti

George Bernard Shaw (1856–1950), polymath, playwright, Nobel prize winner, and the most prolific letter writer in history, was an advocate of English spelling reform. He was reportedly fond of pointing out its absurdities by proving that 'fish' could be spelt

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will require engaging and integrating a broad suite of actors, principles, and practices across three key domains: (i) harnessing social influence, (ii) integrating equity principles, and (iii) aligning incentives through market-based instruments. Empowering and shaping communication between actor groups (e.g., between fishers, practitioners, and policy-makers) using theoretically underpinned approaches from the behavioural sciences is one of the most essential, but often underserved aspects of governing MPAs. We therefore close by highlighting how this cross-cutting tool could be further integrated in governance to bolster high levels of compliance in MPAs.

#### KEYWORDS

cognitive bias, framing, illegal fishing, persuasive communication, poaching, social influence

## 1 | INTRODUCTION

International targets to protect 10%–30% of the world's oceans by 2030 have prompted the rapid establishment of new marine protected areas (MPAs) (Lubchenco & Grorud-Colvert, 2015). Substantial resources have already been invested to increase the number and coverage of marine reserves from 0.67% in 2000 to 7.45% in 2021 (Protected Planet, 2021), and hundreds of billions of dollars will be required to meet these ambitious international targets (Brander et al., 2020). These new MPAs represent progress towards these percentage-based goals, and ideally, biodiversity conservation, yet there is still concern that maximizing coverage could be at the expense of effectiveness (Barnes et al., 2018; De Santo, 2013; Devillers et al., 2015; Gill et al., 2017; Kuempel et al., 2018). For example, although the UNEP World Conservation Monitoring Centre estimates 7.45% of the ocean is currently protected (Protected Planet, 2021), only 2.5% is highly protected by no-take MPAs (Marine Conservation Institute, 2021).

Most of the world's MPAs are considered paper parks, i.e., they exist on paper but not in reality. This is because they are plagued by a combination of persistent poaching (defined here as fishing illegally in no-take areas), inadequate funding, and a lack of management capacity (Edgar et al., 2014; Gill et al., 2017; Mora et al., 2006). Estimates suggest that more than 90% of coral reef MPAs experience levels of poaching that negate expected management outcomes, even when considering only no-take MPAs (Mora et al., 2006), which are the most effective protected areas in the ocean (Sala & Giakoumi, 2018). In addition, most MPAs have inadequate budgets and/or staff capacity to meet basic management needs (Gill et al., 2017; Millage et al., 2021). Thus, increasing compliance in existing MPAs could deliver good conservation outcomes—more so than creating new, but ineffective MPAs.

Many publications have demonstrated that expected ecological outcomes (e.g., fish biomass) are often low or nullified in MPAs with non-compliance (e.g., Edgar et al., 2014; Mora et al., 2006; Rife et al., 2013). However, what is less clear is exactly how much is lost, and what could be gained if these low compliance MPAs were effectively managed. To address this substantial knowledge gap, we use a counterfactual framing approach to quantify the ecological gains

that could be realized by improving compliance. Using the example of no-take MPAs on coral reefs, we demonstrate the ecological implications of poor compliance by calculating the difference in: (i) targeted fish biomass, and (ii) probability of observing top predators between high compliance and low compliance no-take MPAs. We refer to the differences, or expected gains, in ecological outcomes between low and high compliance MPAs as the *compliance gap*.

After quantifying this compliance gap, we then discuss how it might be addressed by more closely considering and managing human behaviour. Specifically, we draw on progress across multiple disciplines (psychology, sociology, and behavioral economics) that specialize in understanding and influencing human behaviour to outline potential pathways and strategies that could be used to shift low compliance MPAs towards higher compliance. Importantly, closing the compliance gap will necessitate expanding beyond managing enforcement to governing compliance more broadly. This governance shift will require engaging a variety of actors and practices across at least three key domains: (i) harnessing social influence, (ii) integrating equity principles, and (iii) aligning incentives through market-based influences. These domains are well-established within the social sciences, but are rarely (if ever) applied to increase compliance in MPAs. Lastly, we highlight the critical, yet often underappreciated role of communication, and how it cuts across these domains.

## 2 | QUANTIFYING THE COMPLIANCE GAP

We used a counter-factual approach to quantify the expected ecological benefits and gains of improving compliance in low compliance coral reef MPAs—i.e., the gains of closing the compliance gap. To our knowledge, this is the first application of such an approach to empirically demonstrate, using real-world data, what has been lost, and what could be gained by increasing compliance in MPAs. Using a large-scale dataset (Cinner et al., 2018), we developed a joint Bayesian hierarchical model to estimate the effect size of compliance on targeted fish biomass and the probability of encountering top predators from 1884 coral reefs in 41 countries (Appendix S1). Our data (collected via non-lethal underwater visual census) included 1207 openly-fished

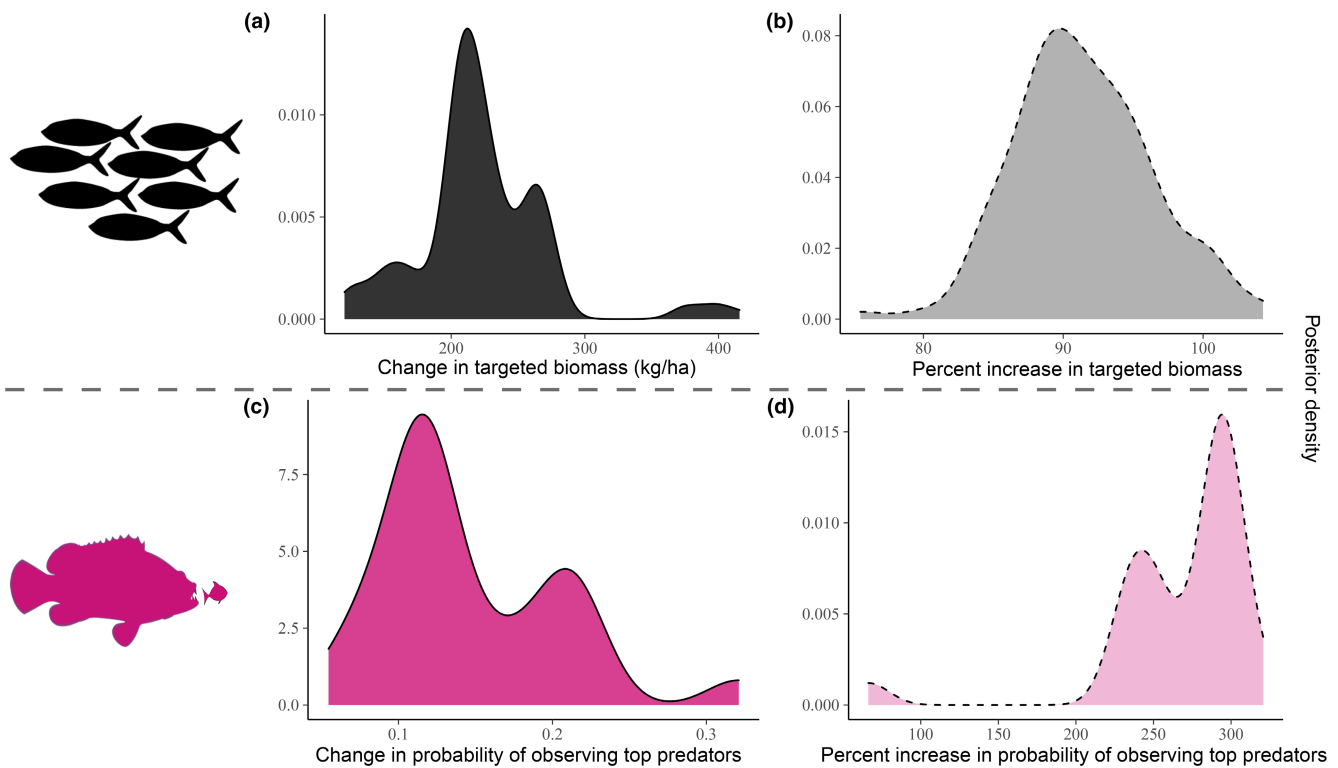
reefs, 485 reefs with restricted fishing (i.e., gear or effort restrictions), and 192 no-take MPA where fishing was prohibited (Appendix S1). For the MPAs, we classified them as either “low compliance” ( $n=124$  reef sites) or “high compliance” ( $n=68$  reef sites) using expert elicitation from scientists and managers working in each location (Cinner et al., 2018). High compliance means that the MPA was not persistently poached. All MPAs in our study were designated no-take areas.

We then developed a predictive model, which provided site-specific estimates for biomass and the probability of encountering top predators based on existing socioeconomic (i.e., amount of human pressure in surrounding seascape, population growth, reef fish landings, level of socioeconomic development, human population size), environmental (primary productivity, atoll, climate stress, habitat type, depth), and management conditions (age and size of MPA, compliance level and presence of restrictions on fished reefs), while controlling for sampling methodologies. We then used model posteriors to simulate a scenario where all low compliance MPAs were high compliance, holding everything else constant. We used the differences between this high compliance scenario and the status quo to estimate the expected gains in targeted fish biomass and top predator presence for each specific location if low compliance MPAs were reformed to high compliance—i.e., the gap in ecological outcomes that results from low compliance (Appendix S1).

We found that fish biomass would nearly double [a median expected increase in biomass of 91% (~217 kg/ha)] if compliance was increased in low compliance reserves (Figure 1a,b), which we refer to as the compliance gap. Even more dramatically, we found that closing the compliance gap would increase the probability of encountering top predators in MPAs by 292% ( $p \sim .2$ ) (Figure 1c,d). To account for potential bias in site selectivity of our low compliance MPA sites, we also simulated the ecological outcomes from hypothetical low compliance and high compliance MPAs among our 1884 openly-fished sites: the results were similar (91% and 245% increase, for biomass and top predators, respectively); Appendix S1. Detailed summaries of sampling and analysis methodologies are available in Appendix S1.

### 3 | CLOSING THE COMPLIANCE GAP

Improving enforcement is often seen as the primary way to increase compliance. We suggest this is necessary, but not sufficient. Instead, a shift towards holistically governing for compliance is required. Governance encompasses formal and informal rules and norms that shape individual and collective action (Lebel et al., 2006). This includes laws, regulations, discursive debates,



**FIGURE 1** The compliance gap, or ecological gains that could be realised if low compliance marine protected areas were effectively governed to achieve high compliance. We used the posteriors from a global model of 1884 coral reef sites under different socioeconomic, environmental, and management conditions to predict how ecological outcomes would be expected to change if compliance were improved in the 124 low compliance MPA reefs in our sample. Expected (a) change in biomass of targeted species, (b) percent increase in biomass of targeted species, (c) change in probability of observing top predators, and (d) percent increase in probability of observing top predators given the effect size of high compliance.

negotiation, mediation, conflict resolution, elections, public consultations, protests, and other decision-making processes (Lebel et al., 2006). Indeed, social norms are often equally or more influential than traditional deterrence-based drivers of compliance (e.g., Thomas et al., 2016), and leveraging these informal influences will strengthen governance for compliance. In the following sections, we review how existing enforcement capacity can be best optimized, then draw on insights from diverse social science disciplines to highlight additional pathways to govern for compliance. Importantly, the pathways we present here (harnessing social influence, integrating equity principles, and aligning incentives through market-based instruments) are not envisioned nor prescribed to work in all of the different MPA contexts that exist across the globe – instead we pull together a diverse range of approaches and tools to showcase numerous currently underutilized options that could bolster compliance in MPAs.

### 3.1 | Optimizing enforcement

Enforcement activities are a critical, and often the most expensive, cornerstone of MPA management. An increasing number of studies have therefore examined how to maximize deterrence through enforcement patrols and interactions with fishers. Two main types of approaches are used to optimize enforcement: actor-based, and place-based. Actor-based approaches focus on the underlying motivations of behavioral drivers for people's compliance decisions, including attitudes and other perceptions such as rule legitimacy, the likelihood of getting caught, and the likelihood and severity of punishment (Arias, 2015; Oyanedel et al., 2020a). Alternatively, place-based approaches seek to understand the environment in which crime takes place, and how to direct patrols and resources to places where poaching is likely (Weekers et al., 2020). Accordingly, these approaches examine conditions or risk factors that create an 'opportunity structure' for poaching, such as the vulnerability of species, the absence of a capable guardian (i.e., those who, formally or informally, have the capacity or tools to intervene and prevent or report a crime), and location characteristics (e.g., exposure to oceanic conditions, accessibility of sites, whether passive surveillance by other stakeholders exists, etc.; Weekers et al., 2020). Combining these two approaches helps move enforcement beyond enforcing rules towards stopping and preventing non-compliance (Oyanedel et al., 2020a).

Managing MPAs with enforcement alone typically results in coerced, or forced compliance; yet compliance can also be cultivated by inducing the voluntary cooperation of stakeholders (Arias, 2015; Bergseth et al., 2018). Ultimately, a combination of coerced and voluntary compliance is likely to be key, as has been demonstrated in other fisheries contexts (Hatcher & Gordon, 2005; Jagers et al., 2012; Kuperan & Sutinen, 1998). The relative influence and relevance of deterrence versus normative based approaches to increasing compliance will be highly place specific, as is thoroughly explored in the previous citations. Regardless, using an approach that mixes both elements is necessary for optimizing enforcement. For example, the

Great Barrier Reef Marine Park Authority (GBRMPA) applies both actor- and place-based approaches to deter poaching and promote voluntary compliance by recreational fishers. Using the 'Protect Your Patch' campaign, GBRMPA engages with fishers through media and at high-use boat ramps to provide information on zoning rules, how to report poaching, and penalties if caught fishing in no-take zones. Furthermore, GBRMPA uses place-based approaches to allocate patrols to high-risk locations (poaching hotspots) during high risk periods (e.g. long weekends and holidays with favorable weather), thereby maximizing the use of limited resources and optimizing enforcement effectiveness (Weekers et al., 2020). However, enforcement is logistically difficult and financially expensive, while many of the world's MPAs are located in developing countries that lack the resources and capacities to maintain comprehensive programs. Identifying alternative pathways to increase compliance in these MPAs is therefore critical. Encouragingly, numerous preconditions and levers for increasing compliance are being further explored in other disciplines or contexts. Here we unpack and discuss how these can be applied to inform the governance of compliance in the world's MPAs.

### 3.2 | Harnessing social influence

Researchers, practitioners, and policy makers alike are increasingly recognizing the importance of social systems and dynamics in shaping people's environmental behaviors. For example, people's exposure to individuals and groups via their social networks, and their positioning in these networks, can determine how (or if) they receive new information, transfer knowledge, and their likelihood of adopting or ceasing a behavior (Barnes et al., 2019; de Lange et al., 2019; Hunter et al., 2019). By identifying and persuading key actors (such as opinion leaders or early adaptors) within populations, practitioners can lever prestige, social proof, and social pressure to increase uptake and diffusion of new behaviors across the whole network (de Lange et al., 2019; Griskevicius et al., 2010; Mbaru & Barnes, 2017). Diffusion can be further bolstered by defining and connecting socially important subgroups within communities and populations (for instance, communities that support these initiatives and have stewardship beliefs, or fisheries leaders or other individuals such as religious or community leaders that have status (de Lange et al., 2019)). Network interventions that have leveraged insights into network dynamics (who people get their information from, early adaptors and opinion leaders, etc.) have been highly successful in promoting a range of health outcomes, including alcohol misuse, well-being, smoking cessation, and adoption of sustainable farming techniques (Bujold & Karak, 2021; Hunter et al., 2019). In addition, leveraging the power of social norms within networks would further increase the likelihood of achieving compliance in MPAs.

Social norms are powerful controls of people's behaviors, especially in environmental contexts. Yet, they are often underappreciated because people tend to underestimate their own susceptibility to social pressure. For instance, normative messaging is more powerful than financial and individual feedback for promoting environmentally

friendly behaviors such as recycling, energy, water, and towel conservation in hotels (Nolan et al., 2008; Schultz et al., 2007). Yet, respondents tend to rate normative messages as less effective in changing their behavior compared to informational messages or personal reasons (Nolan et al., 2008). Norms are demonstrably powerful predictors of fisher compliance (Bergseth & Roscher, 2018; Oyanedel et al., 2020b; Thomas et al., 2016), so careful targeting and nurturing of these norms in MPA networks could lead to rapid, widespread increases in compliance. For instance, practitioners were able to foster and scale sustainable farming practices in Colombian communities by targeting early adaptors, and then using normative feedback loops to snowball early social proof into social pressure (i.e. others are farming sustainably, and you should too; Bujold & Karak, 2021). This same approach could be used to increase compliance in either single MPAs, or networks of MPAs – emphasize how people follow the rules (e.g., Mackay et al., 2019), and/or see poaching as socially unacceptable (but only if these are true – providing false information on norms is not advised). Of course, leveraging norms must be done carefully and tailored to context. Social influence campaigns that emphasize the prevalence of undesirable behaviors (e.g., not recycling) can inadvertently increase them by making them seem like the norm (Cialdini, 2003). Thus, leveraging normative dynamics to increase compliance in MPAs should only be utilized in contexts where practitioners are familiar with both social science research methodology as well as the underlying attitudinal and normative orientation of local fishers.

Importantly, practitioners' abilities to engineer social influences will depend on a number of other important components, including their perceived legitimacy, trust, equity of rules (see integrating equity principles section below) and the degree to which stakeholders are engaged, empowered, and able to participate in MPA management (Fidler et al., 2022; Gezelius & Hauck, 2011). A number of other factors also need to be considered before cultivating and wielding social influence to increase compliance in MPAs. These include the tightness or looseness of cultures (i.e., the relative power and influence of social structures, norms, and influence in shaping cultural norms; Gelfand et al., 2011), as well as the morality and ethical considerations of applying influence techniques and the overall likelihood of gaining community support for compliance in subsistence of economically stressed fisheries (Cepić & Nunan, 2017; Gezelius, 2004; Jagers et al., 2012).

Furthermore, some shortcuts in thinking, often called heuristics or cognitive biases, are intertwined with, and influence social dynamics. For example, social comparison bias describes how people tend to judge their personal state based on comparisons with others. Advertisers have leveraged this bias for years (Martin & Kennedy, 1993). For instance, marketing campaigns for beauty products have long shaped societal trends and ideas about beauty. This same bias could potentially be leveraged to increase compliance in MPAs. Everyone loves a success story (McAfee et al., 2019), so showcasing positive examples of high-compliance (and beneficial) MPAs should allow fishers to compare them with local, low compliance MPAs, thereby increasing their inclination to comply. This

could be further bolstered by reinforcing the prestige and status of these high compliance MPAs, considering that people publicly 'buy green to be seen', or purchase environmentally friendly products to increase their status and public reputation (Griskevicius et al., 2010). For example, the desire for the prestige of having the best MPA in Tahiti, as well as reconnecting with ancient traditions, are among the most important drivers that explain the rapid proliferation of rahu (customary spatial closures based on Polynesian culture and history) throughout French Polynesia (personal communication, Tamatoa Bambridge).

Another related and socially relevant cognitive bias is the bandwagon effect, where people tend to go along with what others are doing to conform and belong to the ingroup, rather than exercising critical thought and risking exclusion (Obermaier et al., 2017; Rikkers, 2002). This is regularly explored in political and medical science to understand voter behavior in elections and doctors' decisions to follow unproven but popular medical ideas. In both cases, voters or doctors made decisions based on the perceived popularity or prevalence of the candidate or medical ideas, rather than candidate history or the empirically supported treatments (Obermaier et al., 2017; Rikkers, 2002). Interestingly, experimental research demonstrates that social tipping points exist—group or societal norms can be shifted when a small number of people are vocal and committed to the norm they are attempting to shift. The required number of individuals needed to inflect this normative tipping point varies according to group size and other contexts, but often occurs at 20–30% of the population (Centola et al., 2018). At this tipping point, the bandwagon effect and other societal phenomenon lead to widespread adoption and diffusion of the norm throughout the group. Thus, practitioners could potentially seed rapid transitions from low compliance to high compliance by empowering, or giving voice to compliant individuals, especially if they are leaders who hold status in the community (Barnes et al., 2019; Mills et al., 2019). Conversely, MPAs with high compliance could be rapidly eroded if non-compliers were vocal and dedicated, for instance if fishers poach as acts of protest, rebellion, or defiance against perceived inequity (Kritzer, 2004; Zafra-Calvo et al., 2019).

### 3.3 | Integrating equity principles

Equity can be broadly defined as having the quality of being fair and impartial. While equity in MPA design and management is ethically important in its own right (Zafra-Calvo & Geldmann, 2020), equitable rules can also increase legitimacy, accountability, local buy-in and participation, and ultimately foster greater compliance (Gezelius & Hauck, 2011; Pascual et al., 2014). In contrast, inequitable rules may reduce legitimacy and promote active resistance and defiance (e.g., sabotage, protest), undermining compliance and support of MPAs (Pascual et al., 2014; Schultz, 2015). Ultimately, equity is a necessary precondition of compliance in MPAs: high levels of compliance are unlikely in its absence. However, the influence of equity principles



has seldom been explicitly examined or empirically linked to compliance levels in MPAs (for exceptions see (Bergseth & Roscher, 2018; Oyanedel et al., 2020b), and if so, only certain dimensions of equity have been considered.

Equity includes dimensions of: (i) distribution, (ii) procedure, and (iii) recognition (Sikor et al., 2014). *Distributional equity*, or the fair distribution of costs, benefits, rights, and responsibilities among subjects (e.g., individuals, groups) can increase compliance. For instance, payments for ecosystem services distributed in accordance to local notions of equity improved attitudes, legitimacy and compliance in terrestrial protected areas (Pascual et al., 2014). Similarly, a lack of *procedural equity*, or fairness of decision-making processes, has led to fishers protesting their perceived marginalization through subtle acts of non-compliance with MPA regulations (e.g., use of destructing fishing gears, sabotage, vandalism) (Raycraft, 2020). Lastly, *recognition equity*, or formally acknowledging, respecting, and valuing differences during interactions and discourse is equally important (Martin et al., 2016). MPAs are often implemented in places with high cultural diversity, where local and indigenous people's rights and concerns may be ignored, to the detriment of all (Martin et al., 2016). For example, the persistence of illegal blast fishing in Tanzanian MPAs is supported by fishers who believe MPAs do not recognize customary land rights (Zafra-Calvo et al., 2019). The dimensions of equity discussed here are not universal. They are subjective and context-dependent, based on what is morally and socially acceptable in a given cultural context (Bennett et al., 2021; Gurney et al., 2021). As such, different principles will inform perceptions of fair distributions (Sikor et al., 2014), procedures, and recognition (Zafra-Calvo et al., 2017). Although local notions and perceptions of equity in MPAs are rarely considered or investigated (Bennett et al., 2021; Gurney et al., 2021), MPAs implemented according to local notions of equity (which likely differ from those of external conservation organizations) are likely to be more effective. For example, stakeholders in Fijian MPAs viewed customary rights-based principles to be most fair compared to opportunity-costs principles when considering the distribution of ecosystem services schemes (Gurney et al., 2021). However, prevailing understandings of distributional justice in conservation and commons management tend to favour the principles of equality or opportunity-cost (Gurney et al., 2021).

### 3.4 | Aligning incentives for compliance through market-based instruments

Market-based instruments span a range of measures and approaches that influence outcomes by modifying incentives to affect costs and benefits (Edwards-Jones et al., 2000). While research on using market-based instruments for marine conservation is increasing, these instruments currently include (i) rights-based instruments (Gelcich et al., 2010), where limits on resource use are supplemented with rights of access or usage (e.g., secured access); (ii) market enhancement instruments, which target and correct market imperfections that lead to unsustainable practices (e.g. ecolabeling), and (iii)

overall changes in pricing designed to further incentivize sustainability compared to unsustainable practices (e.g., taxes, access fees, or other types of permit or licensing systems).

MPA managers can use market-based instruments to align incentives to foster higher levels of compliance (Lubchenco et al., 2016). Market-based instruments can also engage new sets of actors and produce enabling conditions to develop novel partnerships between stakeholders and practitioners (Gelcich & Donlan, 2015). However, short- and long-term demand for the biodiversity benefits of MPAs must be secured to achieve sustainability of these instruments (Sala et al., 2013). Demand could potentially come from different sources such as improved fisheries (Barner, 2015), payment for ecosystem schemes (Sorice et al., 2018), sustainable seafood markets (Kaiser & Edwards-Jones, 2006) and price premiums (Ovando et al., 2016). For instance, well-designed secure-access programs could provide incentives for conservation by ensuring fishers access to a portion of harvests, adjacent fishing areas, or other benefits created by nearby no-take MPAs. When implemented through territorial access rights in MPAs that allow fishing (not no-take), these approaches have created incentives for novel seafood marketing schemes (Gelcich & Donlan, 2015), enabled stewardship of fishers (Rudolph et al., 2020), and supported enforcement in reducing illegal fishing – approaches which could be adapted to support no-take MPAs as well. Although market-based instruments have yet to be adapted to support no-take MPAs, license fees from fishing, tourism and other activities could be used to fund enforcement activities, thereby increasing compliance (Millage et al., 2021). However, it is important to recognize that these instruments can also have undesired consequences such as crowding out intrinsic motivations for conservation behaviors (Cinner et al., 2020). It is therefore important to assess these effects while recognizing the critical role that stakeholder participation plays in shaping the uptake, scalability, and success of these programs.

### 3.5 | Communicating for compliance

Conservation practitioners regularly use communications to disseminate information, educate stakeholders and attempt to influence behaviors. However, communication strategies are often based on the information-deficit communication model—this assumes that people lack information about a specific topic, and providing it will lead to changes in behavior. In MPAs, this often assumes that if people understood that MPAs could/do work, or knew where MPA boundaries were, that compliance would increase. Yet this model has been thoroughly debunked for many environmental behaviors (Heberlein, 2012). Instead, tailoring effective communication requires understanding how cognitive and social dynamics shape people's behaviors, via insights from behavioral sciences such as psychology, sociology, and economics.

Effective communication depends on understanding what type of compliance and non-compliance are occurring, and tailoring messages to target specific drivers for each. For instance,

if non-compliers are intentionally and repeatedly violating regulations, then persuasive messaging (e.g., highlighting the benefits of MPAs) will likely be ineffective in changing fishers' behavior (Ham et al., 2009). Instead, messaging might focus on increasing their perceptions about the likelihood of detection (i.e., their vulnerability to detection), and highlight the severity of sanctions – whether formal (e.g., fines or loss of fishing rights) or informal (e.g., social disapproval or stigmatization) – that may occur (Rogers & Prentice-Dunn, 1997). These messages will be particularly powerful if recipients have personally experienced, or observed others experiencing these consequences (Bandura, 1977). Alternatively, communications that encourage compliance can reduce incidental incursions driven by limited awareness of boundaries, negligence, or other less defiant behaviors. For example, highlighting and reinforcing concepts of personal responsibility, social norms, prestige, and legacy have changed other environmental behaviors (Griskevicius et al., 2010; Nolan et al., 2008; Schultz et al., 2007; Zaval et al., 2015). However, framing and delivering effective messages relies on a thorough understanding of different stakeholders' perceptions and beliefs related to compliance, best gained from theoretically-grounded research.

Along with understanding *what* people think (above), effective communication strategies will lever the cognitive processes of *how* people think to increase receptivity to communication strategies. People have two different systems of cognition: fast or slow thinking (Kahneman, 2011; Tversky & Kahneman, 1974). In situations where people think slowly, which requires significant mental investment (e.g., mulling over the decision to poach (or not) the night before a fishing trip occurs), persuasive messaging is more likely to be successful. In situations where people are likely to make decisions quickly (e.g., making a snap decision to poach based on the presence/absence of enforcement authorities on site), leveraging cognitive biases (i.e., systematic errors in thinking that occur when people are processing information) are more likely to be successful. This is because the effectiveness of messaging depends on understanding how that information is likely to be processed, either slowly (via a high level of elaboration, or mental investment in considering the message), or quickly (using low levels of elaboration or attention to read messages casually). For instance, the elaboration likelihood model (Petty & Cacioppo, 1986) stipulates that we have two routes of processing (central, or 'slow thinking' route, and peripheral or 'fast thinking' route) information, and the capacity of a message to persuade or change behavior depends on recognizing these two scenarios and designing messages accordingly. If enduring behavior change is desired (e.g., among fishers that regularly visit MPAs), messages should require significant mental effort for one to engage with and process. If shorter term behavior is desired (i.e., fishers that only visit an MPA once) practitioners can target the fast system of thinking by leveraging cognitive biases such as framing of norms. Importantly, messages must be salient at the time that fishers decide to comply (or not). If fishers decide to poach (premeditated non-compliance) before arriving at a fishing site, then messaging will be most effective if fishers

receive it when that decision is being made (i.e., at home, or at launching sites). If fishers decide to be non-compliant on the spur of the moment, or to fish when they are not certain of boundaries, then messaging may be more effective if they are reminded at that moment – whether through maps, GPS plotters, or at landing sites.

Finally, the source of information and messaging is perhaps the most important aspect of effective communication—the likeability, credibility, and trustworthiness of a communicator greatly influences the persuasiveness of messaging (Petty & Cacioppo, 1986). Messages delivered by trusted, established, and objective experts or organizations are likely to be more effective than messages from communicators who are seen as biased, self-interested, or otherwise untrustworthy. If communicated in person, the likeability of a communicator is especially important. Cues that guide people's perceptions of these aspects are often peripheral, rather than central, and are based on someone's appearance, body language, behavior, and manner (Petty & Cacioppo, 1986). Hence, many persuasive communications leverage these peripheral cues using celebrity endorsements, communicators dressed as doctors or other relevant experts, and generally 'agreeable' looking individuals (based on the desired audience). Levering these peripheral cues according to local contexts will further bolster the effectiveness of communication strategies. For instance, partnering and delivering messaging via local 'champions' or others in MPA stakeholder communities with some level of status, likeability, or expertise may improve the effects of communication efforts and voluntary compliance.

## 4 | CONCLUSION

While significant international investments flow into establishing new MPAs (Brander et al., 2020), the majority of the world's existing MPAs are low compliance 'paper parks' that are not delivering expected outcomes and benefits. We demonstrate the magnitude of the issue by quantifying the compliance gap—i.e., the substantial ecological gains in terms of fish biomass and the probability of encountering top predators—that could occur by improving compliance in coral reef MPAs. However, closing this compliance gap will require a major shift in how MPA management organizations approach and consider compliance. Optimizing enforcement will remain critical, but enforcement is often the most expensive component of MPA management, and many of the world's MPAs lack the resources to maintain high-end management and enforcement programs (Gill et al., 2017). Shifting our perspective and focus to more broadly governing for compliance, rather than simply enforcing rules, represents a cost-effective approach to addressing the 'paper park' phenomenon. The success of this shift will be heavily reliant on how well we understand, incorporate, and leverage key insights from across the social and behavioral sciences, including, but not limited to those we highlight here, namely principles of equity, social influence, and market-based incentives. Further empirical research on this topic would therefore represent a substantial contribution to a timely, and critical issue.

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## DATA AVAILABILITY STATEMENT

The data used for this paper was permanently archived on the James Cook University Tropical Data Hub, when Cinner et al., 2020 Science was published, and is available at: <https://doi.org/10.25903/5e61a7f08ae39>. The code for analyses in this paper is available online at: [https://github.com/JZamborain-Mason/Bergsethetal\\_2022\\_ComplianceGap](https://github.com/JZamborain-Mason/Bergsethetal_2022_ComplianceGap).

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