



# Linking ecological condition to enforcement of marine protected area regulations in the greater Caribbean region



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## ABSTRACT

Marine protected areas (MPAs) are increasingly employed worldwide to conserve marine resources. However, information on the role of governance mechanisms, in particular those associated with compliance, in shaping ecological condition inside MPAs at the regional scale remains deficient. An exploratory data analysis was conducted to evaluate links between strategies used to promote compliance with MPA regulations (e.g. incentives and penalties) and indicators of ecological condition, including biomass and density of commercial fish species, fish functional groups and coral cover in 21 MPAs across 13 different countries and territories in the greater Caribbean region. The strategies used to promote compliance with MPA regulations were correlated with indicators of ecological condition. For example, MPAs in which a larger number of incentives and penalties are present in the governance system are associated with higher commercial fish biomass and density as compared to those with fewer penalties and incentives available to promote compliance. Although most MPAs in the greater Caribbean use penalties to enforce compliance, these results suggest incentives may also be an important governance strategy for ensuring efficacy of protected areas in conserving key species. Alternatively, the presence of a high number of penalties and incentives in governance systems may also be indicative of greater state capacity and political will in these MPAs resulting in better managed MPAs. Further research is necessary to evaluate results of the exploratory data analysis presented in this study with a more in depth analysis of the de facto use of the regulations evaluated and their efficacy. Multi-country comparisons of MPA governance and ecological indicators can help policy and decision makers maintain MPAs that most effectively achieve MPA conservation objectives.

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## 1. Introduction

Marine protected areas (MPAs) are increasingly employed worldwide as an ecosystem-based management strategy used to prevent the degradation of sensitive marine ecosystems and to manage and conserve ecosystem services such as fisheries, coastal protection, habitat restoration, biodiversity conservation and tourism [1–4]. MPAs are key strategies for sustaining ecosystem services particularly in tropical developing countries where regulation of catch and fishing effort are challenging in the prevalent multi-species, multi-gear, small-scale fisheries [5]. The management of MPAs has relied on a diverse set of governance strategies,

which have included penalties, incentives and appeals to user values, attitudes, and beliefs [6–9]. While much funding and effort has been put into the development of MPAs [4,10–12] those governance strategies that lead to positive social and environmental outcomes remain poorly understood [13,14]. Wide variation has been observed in the effects of MPAs on ecological [15–19] and social factors [20–23], yet explanations of the drivers of this variation remain tenuous. MPAs that fail to meet conservation goals are often labeled “paper parks”, existing only in name [24–26]. Large-scale multi-country comparisons of governance features and scientific studies measuring the impacts of MPAs are necessary to understand the aspects of MPA management that are linked to positive outcomes such as maintaining ecosystem structure, function, and delivery of ecosystem services [2,14,27].

In this paper, the potential of multi-country comparisons in exploring complex social-ecological systems was evaluated by examining the relationships between marine resource governance

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**Table 1**  
Factors influencing resource user compliance with MPA regulations.

Individual level factors & perceptions	Source
Regulations perceived as biologically meaningful	[30]
Regulations perceived as legitimate	[31,32]
Authorities perceived as legitimate	[5,31,32]
Sense of moral obligation	[6,32,35]
Treated respectfully by authorities	[6,32]
Perceived fairness in cost/benefit distribution	[6,32,34]
Regulatory enforcement factors	Source
Enforcement strategy exists	[24,37]
High probability of violators being detected	[6,32]
High penalty for violation	[6,30,39]
Graduated sanctions for violations	[36,47]
Participatory incentives	Source
Opportunity for self-control and self-enforcement	[5,45–48]
Co-management of MPAs with fishers	[5,45–48]
Economic incentives	Source
Provision of alternative livelihoods	[51]
Rights based management schemes	[44,49]
Buyback for fishing gear, licenses or rights	[7,52,53]
Interpretative incentives	Source
Public communication, education and awareness of MPA objectives and benefits	[9,54,55]
Promoting awareness of MPA regulations and restrictions	[8,9,55]
Knowledge-based incentives	Source
Incorporating different types of knowledge	[7–9,55–58]
Managing uncertainty, data deficiency and conflicting objectives	[7,59–61]

and indicators of ecological condition inside MPA boundaries within the Greater Caribbean. This study focuses on governance strategies used to promote compliance with marine resource use regulations that govern who may use marine resources, as well as how, when, and where they may use them. The likelihood of compliance with marine resource regulations is shaped by multiple factors including individual-level factors and perceptions, regulatory enforcement, as well as incentives and regulatory alternatives.

### 1.1. Individual-level factors and perceptions

At the individual level, fisher perceptions of the regulatory process and its outcomes are significant drivers of compliance behavior in marine contexts (Table 1). Moral obligation, social influence, shared norms and perceived legitimacy of authorities charged with implementation of regulations are important factors influencing fisher adherence to regulations [6,28,29]. Regulations must be perceived by fishers as biologically meaningful and effective in conserving fish stocks [30]. Prevailing distrust among fishers for the work of fisheries scientists and the belief that regulations lack biological efficacy in conserving stocks can negatively affect fishers' decision to comply with regulations [30]. Therefore, fisher perceptions of the legitimacy of the regulations matter greatly [6,31,32]. However, compliance is not only influenced by perceived legitimacy of regulations, but also the perceived legitimacy of the process for enforcing regulations [32]. Compliance has been shown to increase when monitoring of behavior and penalties for noncompliance is accountable, legitimate, and equitable [32]. Finally, fisher perceptions of how the process affects themselves and their livelihoods relates to compliance behavior [33].

The distribution of benefits and costs among MPA stakeholders as a result of regulations must be perceived as fair, as must fisher perceptions of how respectfully they are treated by enforcement authorities [6,34,35].

### 1.2. Regulatory enforcement

Governance attributes designed to promote compliance have been shown to encourage sustainable resource use (Table 1). Monitoring and enforcement of MPA regulations organized via graduated sanctions in which rule violators are punished based on the severity and context of offense and the characteristics of the violator are considered a successful tool [36]. A lack of enforcement leading to regulatory noncompliance is often cited as a main cause of failure for many MPA management strategies [11,24,37], while increased enforcement of regulations and subsequent compliance has been correlated to higher fish biomass and richness on a global scale—two indicators of successful conservation [11,38].

Classic enforcement models indicate that individuals are deterred from violating regulations when the probability of detection is high and the penalty is severe, outweighing the potential for illegal gains [6,32]. However, for illegal fishing in many countries the probability of detection and conviction is usually low and sanctions are often lenient and uncertain; thus, the penalties frequently do not offset financial gains, leading to violations [6]. For example, previous failures in marine management due to high levels of non-compliance behavior in ground fish fisheries on the US East Coast can partially be explained by the relatively low economic sanctions compared to large economic gains obtained from illegal fishing as well as distrust among stakeholders groups [39]. Therefore, in the context of marine resources and illegal fishing, while surveillance and severity of sanctions are important, they may not necessarily be the decisive factors influencing compliance [35].

Regulatory enforcement is costly and in developing countries in particular resources available for conservation purposes are often limited [40]. High transaction costs required to monitor and enforce MPAs as well as the high levels of management costs may necessitate a conjunction of methods used to promote compliance [41]. Incentives may provide added levels of efficacy and may be more cost-effective compared to the monitoring and enforcement of penalties [42]. In addition to the costs of a penalties-based approach for MPA management and enforcement, penalties come at a cost for the fishers as well [32,43]. In a penalty scenario, fishers are forced to weigh the costs of sanctions with the benefits of breaking the rules; incentives create scenarios that diminish the opportunity costs of abiding by the rules since by abiding by the regulations they experience gains [42–44]. Therefore, consideration of incentives as an addition to penalties for encouraging desired fisher behavior might be worthwhile.

### 1.3. Incentives

Incentives that address the individual-level factors and perceptions, as discussed earlier, have been shown to aid in encouraging compliance behavior (Table 1). Incentives are defined in this study as regulatory measures designed to encourage resource users to act in accordance with strategic policy outcomes intended for MPA objectives to be achieved [7]. Similar to classifications of incentives from previous studies [7], incentives can be categorized as economic (i.e. market-based solutions and property rights used to achieve MPA objectives), participative (i.e. participation of local users in management decisions), interpretative (i.e. promoting awareness of conservation features, regulations and restrictions, and benefits of the MPA) or knowledge based (i.e. respecting and

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