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Designing and financing optimal enforcement for small-scale fisheries and dive tourism industries

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ABSTRACT

Effective enforcement can reduce the impacts of illegal, unregulated, and unreported (IUU) fishing, resulting in numerous economic, ecological, and social benefits. However, resource managers in small-scale fisheries often lack the expertise and financial resources required to design and implement an effective enforcement system. Here, a bio-economic model is developed to investigate optimal levels of fishery enforcement and financing mechanisms available to recover costs of enforcement. The model is parameterized to represent a small-scale Caribbean lobster fishery, and optimal fishery enforcement levels for three different stakeholder archetypes are considered: (1) a fishing industry only; (2) a dive tourism industry only; and (3) fishing and dive tourism industries. For the illustrative small-scale fishery presented, the optimal level of fishery enforcement decreases with increasing levels of biomass, and is higher when a dive tourism industry is present. Results also indicate that costs of fisheries enforcement can be recovered through a suite of financing mechanisms. However, the timescale over which financing becomes sustainable will depend largely on the current status of the fishery resource. This study may serve as a framework that can be used by resource managers to help design and finance economically optimal fisheries enforcement systems.

1. Introduction

Illegal, unregulated, and unreported (IUU) fishing is a well-known global problem threatening the sustainability of both large and small-scale fisheries and the health of marine environments (e.g. [1–3]). The presence of IUU fishing substantially increases the uncertainty associated with estimating stock status and fishing mortality, which makes determining a sustainable harvest level challenging [4,5]. IUU fishing has been identified as a major factor contributing to the decline, and in some cases, collapse, of a number of fish stocks [6–8]. Other common problems associated with IUU fishing include: ecosystem impacts, economic losses for legal fishermen, and an increased incentive for others to overfish [9,10]. The first study to evaluate the worldwide extent of IUU fishing estimated global IUU fishing in 2003 to be between 11 and 26 million tonnes annually, valued between 10 and 23.5 billion dollars [4] – a substantial amount considering that the estimated global catch of marine capture fisheries in 2012 was 79.7 million tonnes [11]. Given the evolving nature and importance of IUU fishing and unsatisfied with an IUU estimate that was over ten years old, a 2015 FAO-led workshop proposed that the FAO should lead an initiative to determine a new estimate and update that estimate every 5–10 years [12]. A more recent study by Pauly and Zeller estimated global unreported catch, the difference between globally reported catch and a reconstructed global catch, to be 32 million tonnes in 2010, which includes not only illegal catch but also unreported artisanal and subsistence catch, recreational fisheries catch, discards, and bycatch [5]. Given the large scale of the problem, determining effective, feasible methods for eliminating IUU fishing should be considered a high priority.

The primary driver for IUU fishing is economic incentive [10,2]. A fisher who behaves illegally in hopes of financial gain is influenced by the expected costs and benefits of non-compliance [8,13]. An enforcement system, defined as the surveillance of compliance with regulations and the prosecution of those who do not comply with regulations [14,15], can help to decrease the expected benefits from illegal activity and deter such behaviors. The expected profitability of illegal fishing is a function of the enforcement system, and is inversely related to the enforcement effort and probability of detection, the probability of prosecution, and the cost of the penalty (measured in fines, the loss of future earnings due to revoked fishing privileges, etc.) [13]. Therefore, as any of these three aspects increase, the expected profitability of illegal fishing will decrease. The ability for an enforcement system to effectively deter IUU fishing in a particular fishery will also

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depend on the status of the stock, social and economic conditions in the fishery, regulations being enforced, and spatial characteristics of the fishery [13,15–17]

Effective enforcement of a fishery management system has the potential to address the ecological, economic, and social implications of illegal fishing [11,18–21]. Effective enforcement can lead to improved management outcomes by reducing biomass uncertainty caused by unaccounted harvest, which can undermine management efforts. Together with proper management, it can also reduce other negative ecological impacts and assure some level of conservation. [21,22]. The economic and social benefits of reducing illegal fishing are likely to be substantial for developing nations where IUU fishing threatens both food security and livelihoods for those who depend on local fisheries as a protein source and means of income. Thus, effective enforcement can help to recapture dissipated fisheries benefits [14,23]. In the absence of IUU fishing, proper management of a stock will most efficiently maximize revenues [20]. Despite the clear benefits most fisheries would receive from improved enforcement, many fisheries lack an adequate level of enforcement, particularly in small-scale fisheries in developing countries [24,25].

Major barriers to more pervasive and effective enforcement include significant upfront capital costs and high operational costs of ongoing implementation [26,27]. Enforcement is generally the most expensive aspect of fishery management costs and increasing enforcement effort is often costly [15,13]. This is particularly a problem in small-scale fisheries in developing countries that depend on coastal fishing for livelihoods and food security, yet lack the resources to pay for enforcement [28,29]. Often, governments, NGOs, private investors, or a combination provide funding at the onset of new fisheries management initiatives but are unable to fund ongoing enforcement costs [30]. An enforcement system that is designed to eventually be self-financing not only ensures the sustainability of the fishery over time, but can also help to attract the upfront investments needed at the onset of enforcement reform. For a cost-recovery system in which the sectors benefiting from enforcement are responsible for financing this service, potential sources of funding for ongoing enforcement effort include license fees, taxes on landings, fines from illegal activity, and, if applicable, taxes on a relevant tourism industry such as diving. Cost-recovery has been used to finance the costs associated with fisheries management primarily in developed nations including the United States, Australia, New Zealand, Iceland, and Canada [15,31] but has also been used in developing nations including Uganda and Namibia [32,33]. In many cases, traditional funding sources (e.g., funding from local and national governments, foreign investment) are not available for fisheries enforcement. While cost-recovery programs are not yet widespread in small-scale fisheries of the developing tropics, this type of system has the potential to provide funding for fisheries enforcement and management activities in locations where other funding sources either do not exist or do not provide adequate resources for effective management.

The basic economic theory of fisheries enforcement has been previously developed and reported in the literature [34]. This theory posits that instituting a particular enforcement system in a fishery leads to a certain probability that fishers operating illegally will be apprehended and penalized. The probability of receiving a penalty is a function of the enforcement effort applied, the effectiveness of the particular enforcement method in terms of detecting violators, and the likelihood of prosecution. As profit maximizing individuals, illegal fishers take this information into account by including the expected penalty cost into their private benefit function and adjusting their fishing effort accordingly. It should be noted that this theory relies on the assumption that fishers are profit-maximizing, which may not always be the case.

Stakeholder Archetypes
Archetype 1: Fishing industry only
Archetype 2: Dive tourism only
Archetype 3: Fishing and dive tourism industry

Fig. 1. Description of stakeholder archetypes.

Other non-monetary factors may increase compliance including moral standards [26], social punishments for rule violators including ostracism and social degradation [35,36], fisher involvement with co-management [37], and fisher participation in cooperatives [38].

Previous studies examined how optimal enforcement levels depend on stock status, the economic parameters of a fishery, and the enforcement system in place [39]. This optimal level was determined by maximizing the total social benefits in the fishery, accounting for both fishing profits as well as the cost of enforcement. This study investigates optimal enforcement levels using a bio-economic model in the context of an illustrative small-scale Caribbean lobster fishery in Barbuda and builds upon previous research in two important ways. First, the optimal enforcement effort level is determined as a function of the lobster stock status for three different stakeholder archetypes common in tropical small-scale fishery settings, each with private industries deriving benefits from the stock: (1) lobster fishing industry only; (2) dive tourism industry only; and (3) lobster fishing and dive tourism industries (Fig. 1). Second, the model is used to explore the potential of sustainably financing enforcement in a small-scale setting through financing mechanisms potentially available in small-scale fisheries: (1) fishing license fees; (2) a landings tax; (3) penalties received through the enforcement system; (4) a tax on dive tourism revenue. Therefore, the model is used to investigate the following questions: (1) how will optimal enforcement and fishing effort change given the stakeholder archetype and status of a stock; and (2) how can this optimal enforcement level be financed. This analysis may be used to help managers determine optimal enforcement levels for a fishery given the status of the stock and stakeholder archetypes, as well as to inform sustainable enforcement financing mechanisms and appropriate time-scales of recovering enforcement costs.

This paper will first describe the study site, an illustrative Caribbean lobster fishery in Barbuda. Next, the bio-economic model will be defined, which is composed of a biological model, dive tourism and fishery economic models, and an enforcement model. This section also includes a sensitivity analysis to the assumed starting lobster biomass and enforcement financing parameters. A description of how the model was parameterized for the study site is also provided. Next, modeling results are described that show how optimal enforcement and fishing effort depend on stakeholder archetype and stock status, as well as how this optimal enforcement can be financed. These results, along with a discussion of important assumptions and how these results are particularly important for the context of small-scale fisheries, are presented in the Sections 4 and 5.

2. Methods

2.1. Study site description

This study focuses on determining optimal enforcement levels and cost-recovery mechanisms for an illustrative Caribbean spiny