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A comparison of approaches used for economic analysis in marine protected area network planning in California

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Abstract

In addition to fostering biodiversity goals, marine protected area (MPA) implementation has economic consequences for both commercial and recreational fisheries. During the implementation of the State of California (USA) Marine Life Protection Act (MLPA), which mandates the creation of an MPA network in California's state waters, the stakeholders and policymakers utilized a pair of economic analyses that addressed these considerations. One was a comparative, static assessment of short-term, "worst case" potential socioeconomic impacts to important fisheries based on surveys of local fishermen. This analysis made no assumptions about fishery management outside of MPAs, assumed no spillover of fish from MPAs into fished areas or reallocation of fishing effort, and estimated the maximum potential dollar-value economic impacts over a short time scale. The other was a dynamic, bioeconomic assessment of the changes in spatial distribution of biomass and catch, based on published biological parameter values, oceanographic models of larval connectivity, and a range of possible levels of fishing. This analysis explicitly accounted for fish population dynamics, spillover, fisher movement, and fishery management outside of the MPAs, but was limited to long-term, equilibrium-based results because of a lack of baseline abundance data. Both evaluation methods were novel in their spatial resolution and their use directly in an MPA design process, rather than after implementation. The two methods produced broadly similar (at a regional spatial scale) evaluations of the likely effects of proposed MPAs on fisheries, at least when the bioeconomic model assumed fishery management was conservative. Our experience with these analyses in the MLPA Initiative process led to several suggestions for future MPA design efforts: (i) since the change in fish biomass inside MPAs partly depends on fisheries management outside of them, it is useful to integrate or coordinate conventional fishery management and MPA planning efforts; (ii) integrate modeling assessments early into MPA design, as part of a post-implementation adaptive management approach; and (iii) integrate empirical fishery data into bioeconomic models in order to improve representations of human behavior and short-term forecasts of changes in fished populations.

Highlights

► Two analyses to guide marine protected area (MPA) design in California. ► 1) Static analysis of worst-case socioeconomic impacts based on surveys. ► 2) Dynamic analysis of ecological and fishery effects using population models. ► Analyses produced similar evaluations under certain fishery scenarios. ► Future efforts could better integrate ecology, socioeconomics, and fisheries.

Introduction

The implementation of marine protected areas (MPAs) has, by necessity, both human and ecological consequences. Restricting or excluding extractive activities such as fishing from a location is often associated with habitat recovery and increases in species diversity and the density, biomass, and average size of organisms (Halpern and Warner, 2002; Halpern, 2003; Lester et al., 2009). Since fishing is also an important economic activity in many coastal areas, such limitations on fishing effort result in both short and long term impacts on the fishing economy. While there is a growing literature on the economic costs and benefits of MPAs (see review in Sanchirico et al., 2002), MPAs are typically established in anticipation of biological or ecological benefits without explicit consideration of economic factors (Sumaila et al., 2000). Economic effects are typically evaluated only post hoc for MPAs that were designed to meet biological and ecological objectives (Scholz et al., 2004; Stewart and Possingham, 2005).

The economic impacts of MPAs will depend on their spatial configuration — some places will accumulate biomass more effectively and some places will be more costly if excluded as fishing grounds (Costello et al., 2010; Smith and Wilen, 2003; White et al., 2010a). Therefore, effective MPA design requires understanding both the current spatial pattern of fishing in the ocean and how those patterns change in response to MPA implementation. Current fishery management planning practices, however, tend to be nonspatial. For example, the guidelines for economic analysis for federal fisheries management recognize that “combining biological information with fishery economics is needed for both qualitative and quantitative analysis of fishery management actions (Office of Sustainable Fisheries, 2000, p. 4)”, but then remain silent on the spatial dimension of both biological and economic systems. Additionally, the data routinely used in fisheries management are inadequate for spatial analysis. For example, fishery assessments commonly assume that populations are well-mixed at a scale of several hundreds of km along a coastline. Similarly, fishery catches are not commonly reported at a fine-enough spatial scale and require considerable transformation before they can be used in a spatial context (Scholz et al., 2005). Even then they are not suitable to resolve potential economic impacts of individual MPAs.

Because of the inherently spatial nature of MPAs, models for assessing the impacts of MPAs on fished populations have developed at finer scales of resolution than typical fishery stock assessment models. To date, the state of spatial population modeling efforts for MPAs has been predominantly “strategic”, simply predicting the range of sizes and/or numbers of MPAs and the spacing necessary for population persistence under different fishing regimes along an idealized coastline (e.g., Botsford et al., 2001; Gaylord et al., 2005; Mangel, 1998; Sladek Nowlis and Roberts, 1999; White et al., 2008). There have been few examples of site-specific MPA population models (e.g., Little et al., 2007; Stockhausen et al., 2000; see Pelletier and Mahevas, 2005 for a review of MPA models), primarily because of limited information on larval dispersal.

From 2004 to 2011, the state of California, USA, underwent a public MPA design process resulting in the designation of a statewide network of no-take and restricted-take MPAs. This process was mandated by the 1999 passage of the Marine Life Protection Act (MLPA) in the California legislature (see Kirlin et al., 2013, for details; see Table 1 for a list of acronyms used in this paper). The MLPA was implemented through a series of regional planning efforts.

In this paper we describe and synthesize two complementary approaches to including economic and population dynamic factors in the evaluation of proposed MPA networks. We developed and applied these two analytical approaches in our roles as scientific advisors to the regional MLPA planning processes:

i) a comparative static assessment of potential maximum short-term economic impacts to regionally-important fisheries that is agnostic of external fishery management and assumes no spillover of fish from reserves to fished areas or reallocation of fishing effort, but does express fishing effort, real local catches and economic values (henceforth the “static” analysis).

ii) dynamic bioeconomic modeling of long-term equilibrium outcomes that explicitly accounts for fish population dynamics, spillover, fisher movement, and fishery management outside of the MPAs (henceforth the “dynamic” analysis).

Importantly, both approaches explicitly consider the spatial nature of fishing activities. Both this aspect and the timing of the economic analysis in the regional planning processes constitute a significant departure from past MPA planning practices worldwide. In this paper, we discuss the advantages and shortcomings of these approaches, lessons learned from the California MPA network planning experience, and next steps for MPA planning in California and elsewhere. This paper is novel in its synthesis of two approaches to economic analysis and the presentation of lessons learned.

Section snippets

The MLPA process

The details of the enabling legislation and structure of the MLPA planning process are described in detail elsewhere in this volume (Fox et al., 2013a, Fox et al., 2013b; Kirlin et al., 2013), but to summarize briefly, the design process proceeded in stages, each stage corresponding to one study region of the California coast (Central, North Central, South, and North, in chronological order). The design process for each region took 1–2 years and involved a Regional Stakeholder Group (RSG) who…

Comparison of the two analyses

The static and dynamic analyses both attempted to represent the effects of closing fishing grounds on overall fishery yield and/or profit in the study region, although the two analyses focused on different aspects of the issue (summarized in Table2). The former focused on short term economic effects, while the latter projected the long-term effects based on population dynamics, for a variety of assumed fishery regimes. In Fig.5 we compare the results of both evaluations for a range of MPA…

Evolving perceptions of both analyses

When they were first introduced into the MLPA process in the CCSR, both the static and dynamic analyses came under intense scrutiny from stakeholders and scientists alike. Eventually, both methods became accepted parts of the process and effort shifted from explaining and defending methodology to improving the accessibility of results to stakeholders. Initial skepticism about the use of these analyses arose from two sources: the lack of explicit mention of economic impact or fisheries in the…

Discussion and conclusions

The comparative static analysis and dynamic bioeconomic model were distinct but complementary tools for economic analysis in the MLPA process. Formal economic assessments were not mandated by the MLPA, but in the later study regions both of these analyses were being utilized by stakeholders, scientists, and policymakers. The static analysis was essentially a first-order, worst-case representation of the potential economic loss imposed by closing off fishing grounds in MPAs. It provided a…

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