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Applying empirical estimates of marine protected area effectiveness to assess conservation plans in British Columbia, Canada

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ABSTRACT

While efforts to meet international commitments to counter biodiversity declines by establishing networks of marine protected areas (MPAs) continue, assessments of MPAs rarely take into account measures of effectiveness of different categories of protection, or other design principles (size, spacing, governance considerations). We carried out a meta-analysis of ecological effectiveness of IUCN Categories I–II (no-take), IV and VI (MPAs) compared to unprotected areas. We then applied our ecological effectiveness estimates – the added benefit of marine protection over and above conventional fisheries management – to a gap analysis of existing MPAs, and MPAs proposed by four indigenous groups on the Central Coast of British Columbia, Canada. Additionally, we assessed representation, size, spacing, and governance considerations against MPA design criteria outlined in the literature. We found significant differences in response ratios for IUCN Categories IV and VI MPAs compared to no-take reserves and areas open to fishing, although variability in responses was high. By rescaling the predicted ecological effectiveness ratios (including confidence estimates), we found that, compared to no-take reserves (biodiversity conservation effectiveness 100%) and open fishing areas (0% additional biodiversity contribution over and above conventional fisheries management), IUCN Category IV had a predicted effectiveness score of 60%, ranging between 34% and 89% (95% lower and upper confidence intervals, respectively), and IUCN Category VI had a predicted effectiveness score of 24% (ranging between −12% and 72% for the 95% lower and upper confidence intervals, respectively). We found that the existing MPAs did poorly when compared against most MPA design criteria, whereas the proposed MPA network achieved many of the best practices identified in the literature, and could achieve all if some additional sites were added. By using the Central Coast of British Columbia as a case study, we demonstrated a method for applying empirically-based ecological effectiveness estimates to an assessment of MPA design principles for an existing and proposed network of MPAs.

1. Introduction

Networks of marine protected areas (MPAs) are increasingly being designed and implemented throughout the world to meet a diversity of conservation, food security and fisheries management objectives (Grorud-Colvert et al., 2014). MPAs range from strict no-take areas where all extractive activities are prohibited and people are restricted from visiting, to areas with sustainable use of natural resources. As a collection of individual MPAs operating cooperatively and synergistically, at various spatial scales, MPA networks typically encompass a range of protection levels (Dudley, 2008; Kelleher and Kenchington, 1992). While individual MPAs and MPA networks are often established to meet biodiversity conservation and sustainable use objectives, other goals also exist (Jupiter et al., 2014). In particular, in some regions, indigenous and local people are using marine spatial planning, including MPAs, as a way to secure access to marine resources and assert their management and constitutional rights (e.g., territorial user rights for fisheries, TURFs, Castilla and Defeo, 2004; Gelcich et al., 2012; locally managed marine areas, Johannes, 2002).

When biodiversity conservation is an overarching objective, designing effective MPA networks requires information about region-specific ecological MPA network design principles and governance good practices to ensure effective planning processes, subsequent management, and compliance (Burt et al. 2014).

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Ecological MPA design principles are well-established in the literature, although region-specific guidelines are less prevalent. Many academic publications outline representation, size, shape and spacing design guidelines (e.g. Airamé et al., 2003; Ballantine, 1997; Botsford et al., 2003; Friedlander et al., 2003; Halpern, 2003; Roberts et al., 2003; Shanks et al., 2003). Moreover, a growing number of review articles (Foley et al., 2010; McLeod et al., 2008), reports by international agencies (International Union for the Conservation of Nature, IUCN; Commission for Environmental Cooperation, CEC) and collaborative endeavors (Fernandes et al., 2012) synthesize scientific guidelines so they can be applied to regional MPA networks by managers and policy makers. Increasingly, governance principles are also incorporated into guidelines. These can be summarized into six thematic principles and practices: (1) legitimacy; (2) inclusion and fairness; (3) capacity and performance; (4) coordination and collaboration; (5) knowledge integration and adaptability; and (6) transparency and accountability (Burt et al., 2014).

Applying ecological MPA design principles requires ecological data, yet data are almost always limited. Habitat types are commonly used as proxies for species and biodiversity, and studies have shown that use of such surrogates better represents biodiversity than selecting MPAs at random (Beger et al., 2007; Sarkar et al., 2004; Ward et al., 1999). Similarly, a study that tested the effect of limited spatial data in identification of conservation priority areas showed that, even with very few biological or physical datasets, the general patterns of priority areas to protect remained consistent (Ban, 2009). Traditional ecological knowledge (TEK) is another source of information that can be used directly (i.e., as data points) or indirectly (i.e., by asking indigenous people for MPA placement preferences) in MPA design (Ban et al., 2009). Thus, there is a general consensus that it is better to move forward with planning despite data limitations, rather than postponing planning efforts and risk further biodiversity loss.

The ecological benefits of no-take MPAs have been well-studied (e.g., Halpern and Warner, 2002; Stewart et al., 2009), but we know much less about the ecological effectiveness of other kinds of MPAs (Lester and Halpern, 2008; Sciberras et al., In press). Yet many MPA networks are designed with multiple objectives in mind (e.g., biodiversity conservation, sustainable fisheries, improved livelihoods, food security, adaptive capacity for climate change) and thus are comprised of – and strive to establish – multiple areas spanning a spectrum of protection levels. The IUCN developed a system to categorize protected areas in 1994 (IUCN World Commission on Protected Areas and World Conservation Monitoring Centre, 1994), updated in 2008 (Dudley, 2008). The purpose was to reduce confusion about the many kinds of protected areas that exist internationally, provide standards for reporting on progress of protected area establishment, and facilitate a way to use and compare data on protected areas. The categories have been refined since the initial iteration, and, despite some debate about the details of the category system (Boitani et al., 2008), they are widely used in reporting progress on protected areas to international bodies such as the Convention on Biological Diversity (CBD). Thus, an important knowledge gap for designing future networks of MPAs is the evaluation of trade-offs between ecological and socio-economic effectiveness of partially protected areas designed to meet conservation, food security and fisheries management objectives.

Several studies have begun to look at the effectiveness of partially protected areas, with two reviews to date. Lester and Halpern (2008) synthesized 20 peer-reviewed publications that reported biological responses of no-take versus partially protected areas. They found that partially protected areas resulted in higher ecological metrics than open access areas, but did not have the same level of ecological benefits as no-take areas. Similarly, Sciberras et al. (In press) examined the effectiveness of fully and partially protected areas compared to areas fully open to extraction and use by humans. They found that no-take areas yielded significantly higher biomass of fish within their boundaries than partially protected areas, and that partially protected areas also significantly enhance density and biomass of fish relative to open areas. However, neither of these studies differentiated between kinds of partial protection by IUCN Category nor were multiple MPA objectives addressed. The main objective of our research was to empirically estimate effectiveness of different IUCN Categories, and demonstrate how effectiveness ratings can be used to assess marine spatial plans.

The marine waters of Pacific Canada, in the Province of British Columbia (BC) are one region where networks of MPAs are being designed and discussed but have not yet been implemented (Ban et al., 2013a). Here, indigenous people, referred to as First Nations in Canada, are engaged in developing visions for management of the marine portion of their territories (e.g., see http://www.coastalfirstnations.ca/). Despite jurisdictional uncertainties due in part to the lack of treaties, many coastal First Nations are proceeding with developing marine use plans, including biodiversity conservation components, with the intention that they will implement them in partnership with provincial and federal governments. The Central Coast of B.C. is one of several regions, where four First Nations (Heiltsuk, Kitasoo/Xai'Xais, Nuxalk and Wuikinuxv Nations) have collectively developed a draft marine use plan, including areas proposed for conservation (hereafter referred to as "proposed MPAs") (see http://ccira.ca/ for more information). An intensive traditional ecological knowledge (TEK) study provided information by and for the First Nations in development of their draft plans, which also incorporated the best quantitative ecological and socio-economic data available. Existing MPAs in the region were considered and included in the draft plans, often with a recommendation for stricter protection. At the request of the four Central Coast First Nations, we assessed the proposed MPA network against ecological and governance good practices identified in the literature (see Burt et al., 2014 for details). Specifically, we asked, how well do existing and proposed MPAs, classified by IUCN protection Category, meet ecological and governance good practices? And, what areas could be added to achieve biodiversity conservation objectives? To empirically estimate the potential ecological effectiveness of the existing and proposed MPAs in BC, we derived a metric of effectiveness afforded by partial protected areas based on a meta-analysis of MPAs from around the world, spanning IUCN protection Categories.

2. Methods

2.1. Ecological effectiveness of IUCN Categories

We used the IUCN protected area categories as a framework for categorizing MPAs by the level of human uses allowed within them (Day et al., 2012; Dudley, 2008). These range from strict protected areas that are commonly no-go areas (Category Ia), to areas that protect ecological processes by prohibiting almost all extractive activities (Categories Ib and II), to areas that allow some limited extraction (Category IV), to those that focus on sustainable use (Category VI) (Table 1). In our analysis, we focused on IUCN Categories Ia and b, II, IV and VI as they represent a gradient of allowed human uses, while Categories III and V are more ambiguous in allowable uses, and are less prevalent (Table 1).

We conducted a meta-analysis of peer-reviewed scientific literature documenting and comparing the effects of fully-protected no-take areas to partially protected areas, and partially protected areas to no protection (i.e., to areas with conventional fisheries