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Research Note

Impacts of Marine Protected Areas on Fishing Communities

MICHAEL B. MASCIA,*† C. ANNE CLAUS,*‡ AND ROBIN NAIDOO*

*World Wildlife Fund, Conservation Science Program, 1250 24th Street NW, Washington, D.C. 20037, U.S.A.

Abstract: *Marine protected areas (MPAs) are a popular conservation strategy, but their impacts on human welfare are poorly understood. To inform future research and policy decisions, we reviewed the scientific literature to assess MPA impacts on five indicators of human welfare: food security, resource rights, employment, community organization, and income. Following MPA establishment, food security generally remained stable or increased in older and smaller MPAs. The ability of most fishing groups to govern MPA resources changed. Increased resource rights were positively correlated with MPA zoning and compliance with MPA regulations. Small sample sizes precluded statistical tests of the impacts of MPAs on employment, community organization, and income. Our results demonstrate that MPAs shape the social well-being and political power of fishing communities; impacts (positive and negative) vary within and among social groups; and social impacts are correlated with some—but not all—commonly hypothesized explanatory factors. Accordingly, MPAs may represent a viable strategy for enhancing food security and empowering local communities, but current practices negatively affect at least a minority of fishers. To inform policy making, further research must better document and explain variation in the positive and negative social impacts of MPAs.*

Keywords: social impacts, food security, resource rights, livelihoods, poverty, displacement, marine reserves, national parks

Impactos de las Áreas Marinas Protegidas sobre Comunidades de Pescadores

Resumen: *Las áreas marinas protegidas (AMPs) son una estrategia popular de conservación, pero sus impactos sobre el bienestar humano son poco conocidos. Para información de investigaciones decisiones políticas en el futuro, revisamos la literatura científica para evaluar los impactos de AMP sobre cinco indicadores de bienestar humano: seguridad alimentaria, derechos sobre los recursos, empleo, organización comunitaria e ingreso. Después del establecimiento de AMP, la seguridad alimentaria generalmente permaneció estable o incrementó en las AMP más antiguas o pequeñas. La habilidad de la mayoría de los grupos de pescadores para gobernar los recursos de las AMP cambió. Hubo correlación entre incremento en los derechos sobre los recursos con la zonificación de las AMP y el cumplimiento de las regulaciones de las AMP. Tamaños de muestra pequeños impidieron la aplicación de pruebas estadísticas de los impactos de AMP sobre el empleo, la organización comunitaria y el ingreso. Nuestros resultados demuestran que las AMP moldean el bienestar social y el poder políticos de las comunidades de pescadores; que los impactos (positivos y negativos) varían dentro y entre los grupos sociales; y que los impactos sociales están correlacionados con algunos – pero no todos – los factores explicativos que comúnmente se incluyen en las hipótesis. Consecuentemente, las AMP pueden representar una estrategia viable para realzar la seguridad alimentaria y empoderar a las comunidades locales, pero las prácticas actuales afectan negativamente por lo menos a una minoría de pescadores. Para informar la definición de políticas, las investigaciones futuras deben documentar y explicar la variación en los impactos sociales positivos y negativos de las AMP.*

†*email michael.mascia@wwfus.org*
‡*Current address: Yale University, Departments of Anthropology and Forestry & Environmental Studies, 10 Sachem Street, New Haven, CT 06520-8277, U.S.A.*
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Palabras Clave: derechos sobre los recursos, desplazamiento, formas de vida, impactos sociales, parques nacionales, pobreza, reservas marinas, seguridad alimentaria

Introduction

Marine protected areas (MPAs)—oceanic wildlife refuges, national parks, and sanctuaries—are an increasingly popular strategy for managing fisheries and conserving biodiversity, but their contribution to poverty alleviation and sustainable development remains contested. Advocates tout MPAs as a win–win strategy for biodiversity conservation and poverty alleviation (Roberts et al. 2001; Leisher et al. 2007), whereas critics argue MPAs often place the welfare of fishes above the well-being of fisheries-dependent coastal communities (Paddock 2006; West et al. 2006). Approximately 1 billion people depend on fish as their primary source of animal protein (FAO 2000, p. 32) and governments are committed to at least a six-fold increase in the global coverage of MPAs by 2012 (from 1.6% to 10%+ of the coastal ocean; Wood et al. 2008), so the impact of MPAs on human well-being is a scientific question of critical policy importance (West et al. 2006; Mascia & Claus 2009).

Although the ecological impacts of MPAs are relatively well characterized (Halpern & Warner 2002; Halpern 2003), MPA social impacts are poorly understood and have been the subject of relatively limited inquiry (National Research Council 2001; Christie et al. 2003; Mascia 2004; West et al. 2006). By restructuring human interactions with the marine environment, MPAs influence the quantity and type of tangible and intangible benefits that flow from marine ecosystems, as well as the distribution of these benefits among social groups (National Research Council 2001; Mascia & Claus 2009). Of particular interest are the effects of MPAs on fishes and fisheries within an MPA and in adjacent waters. These effects include the abundance and diversity of fishes; the amount of fish caught and the associated level of effort required; the income earned by fishers from fishing and by other social groups (e.g., scuba dive boat operators) that do not harvest fish; and the distribution of benefits within and among user groups (Hastings & Botsford 1999; Halpern 2003; Mascia 2004; Mascia & Claus 2009). Underlying this interest are concerns that efforts to enhance marine biodiversity (and, in some cases, boost marine recreation and tourism) through MPAs may negatively affect the livelihoods and social well-being of fishers—especially those who are poor and marginalized and, therefore, most dependent on marine resources (Christie et al. 2003; Christie 2004; Stoffle & Minnis 2008; Mascia & Claus 2009). To provide a social scientific basis for policy decisions and future research, we reviewed the MPA literature and investigated the effects of MPA establishment on fishers with respect to five commonly reported indicators of social well-being: food security, resource control, employment, community organization, and income.

Methods

We searched the *Web of Science*, *Proceedings of the International Coral Reef Symposium*, and lists of works derived from these sources for peer-reviewed research articles that had three attributes: information on conditions before and after MPA establishment or on conditions inside and outside MPA boundaries; detailed information specific to the level of sites and user groups; and empirical data on the social impacts of MPAs. We omitted ecological studies that referred only to increases in fish abundance, for example, because such studies did not indicate whether fishers or other stakeholder groups benefited from this increase. Based on this review, we focused our analysis on the five aspects of social well-being most commonly reported in the MPA literature: food security (reported as catch per unit effort [CPUE]), resource control (i.e., the right to govern natural resources within the MPA), employment (reported as number of active fishers), community organization (i.e., number of active civil society organizations composed exclusively or primarily of fishers), and income (i.e., money earned by fishers, as defined by the authors of the studies we reviewed). We included all forms of MPAs (e.g., no take, multiple use) in our review and defined an MPA as "any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (IUCN 1988).

Our data screening and coding followed established methods for reviewing the biological impacts of MPAs (Halpern 2003). We coded all impact data qualitatively as decrease, increase, or no difference. Source materials reported the impacts of MPAs either qualitatively (e.g., "the number of net fishers increased after the creation of the MPA") or quantitatively (e.g., "25 net fishers joined the fishery in the year following MPA establishment, an increase of 18.7%"). We recorded both types of data as an increase in employment since MPA establishment. We categorized an impact only if it was reported explicitly; we did not infer or assume impacts. We report impacts as they were described at the time of research. One case examined MPA dissolution; we considered this a temporally inverted test of MPA impacts over time and coded these impacts accordingly. In instances where identical

data were reported in multiple articles, we omitted these repetitive cases to avoid double counting. Because the impacts of MPAs may shift over time, we treated data collected five or more years after the initial collection event as independent observations and included these data points in our analyses. We limited our analyses to the impacts of MPAs on fishers because of a paucity of data on other stakeholder groups (e.g., marine tourism operators; $n < 15$ data points across the five social indicators we examined). From our initial pool of more than 150 articles, we identified 21 studies that met our research criteria. We included information from only these 21 studies in our data set and subsequent analysis (see Supporting Information).

Where reported in these 21 studies, we categorized fishers by type of fishing gear used and by community where they lived or from which they fished (e.g., town, village, neighborhood). Categories of fishing gear included mobile nets (e.g., trawl nets); stationary nets (e.g., gill nets); hand gear (e.g., spear guns); and lines (e.g., trolling). Where gear type was not specified or where multiple gear types were lumped together in the original source material, we used a more generic category to capture the data within a single data point (e.g., all net fishers; all fishers). We disaggregated and aggregated data regarding communities of origin analogously.

We used chi-squared tests to assess whether the overall distribution of social impacts (increase, decrease, or no change) was significantly different from a random distribution of social impacts among all fisher subgroups and within specific categories of subgroups. Data were pooled and tests were performed with all fisher data. For the income, community organization, and employment response variables, there were insufficient numbers of observations to perform statistical tests, so we present the information in a histogram for visual inspection. With one exception (i.e., CPUE of stationary net fishers), sample sizes were also too small to conduct statistical analyses on response categories with respect to specific types of fishing subgroups, so we again illustrated trends in distributions in histograms. We used exact tests (for our categorical variables with small sample sizes) and analysis of variance (ANOVA) (for continuous variables, using the MPA change categories—decrease, no change, increase—to test differences in means of our variables of interest) to test the relationship between the MPA impacts (i.e., food security, resources rights) and potential explanatory variables. In our analysis we included seven possible explanatory variables that we derived from the literature: MPA size (square kilometers), age (years since establishment), geographic location (temperate or tropical), zoning (i.e., presence or absence of rules spatially segregating human uses), no-take designation (i.e., presence or absence of rules prohibiting extractive uses in some or all of the MPA), formal enforcement (presence or absence), and high levels of compliance with MPA regulations (presence or absence). For all statistical tests, we used a p value of 0.10 to assess significance of results because our sample sizes were small and statistical power was low. When a statistical test showed significant differences existed among categories of independent variables, we interpreted differences by visual examination of the data (i.e., we did not conduct formal post hoc tests, again due to small sample sizes).

Of the more than 150 studies we examined, only 21 measured the impact of MPA establishment on a specific fishing subgroup (i.e., "fisher from village X using fishing gear Y" or sometimes reported simply as "fishers from village X"). These subgroups corresponded roughly to "communities of practice"—bounded groups of interacting practitioners engaged in similar activities (Lave & Wenger 1991)—which often exhibit heterogeneity in social well-being. A plurality of these studies examined a single social impact (43%). Fewer studies examined two (33%) or three (24%) impacts and no studies examined four or more social impacts. Most of these studies were conducted in tropical (71%), developing (73%) countries. Twenty MPAs in 11 countries were represented in our review (<0.5% of the >4400 MPAs established worldwide [Wood et al. 2008]). Most data came from MPAs in the Philippines (33% of all social impact measures), Kenya (14%), and Egypt, Italy, and St. Lucia (each 13%; Supporting Information). We categorized these qualitative and quantitative measurements for analysis, ultimately generating a data set with 96 observations of MPA social impacts on 70 distinct fishing subgroups. Governance (e.g., multiple uses, no take), size (<1 km^2–13,900 km^2), age (1–22 yrs.), and geography of the MPAs in our sample varied (Table S1).

Results and Discussion

MPAs affected the social well-being and political power of fishers (Fig. 1). Following MPA establishment, food security generally remained stable or increased (df=2, $\chi^2 = 12.46$; $p = 0.002$), but declined for 16% of the fishing subgroups. Among fishers using stationary nets, a similar pattern emerged (df=2; $\chi^2 = 6.7$; $p = 0.035$); 15% experienced a decline in food security. Most fishing subgroups experienced a shift in their ability to govern MPA resources (df=2; $\chi^2 = 6.0$; $p = 0.050$); 44% of all subgroups gained greater control over marine resources following MPA establishment and the same percentage experienced a loss of resource control. Extremely small sample sizes precluded basic statistical testing of MPA effects on employment, community organization, and income, although the data suggested community organization increased following MPA establishment. No trend was apparent for employment or income.

The social impacts of MPAs were shaped by some—but not all—factors commonly hypothesized to

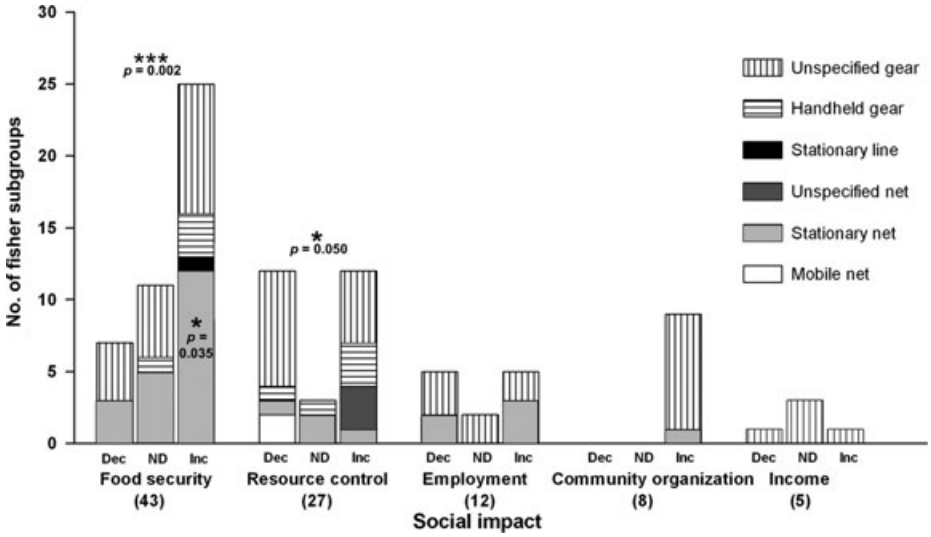

*Figure 1. Impacts of marine protected area establishment on fisher subgroups. Histograms depict frequency of qualitative changes in catch per unit effort (proxy for food security); resource rights (measure of resource control); number of active fishers (proxy for employment); degree of community organization; and income. Subgroup data are presented for illustrative purposes. With the exception of food security impacts among stationary net fishers (*p = 0.035*), statistical analyses are not possible at the level of specific subgroups due to small sample sizes (in parentheses) (*, statistically significant results of chi-square tests; Dec, decrease; ND, no difference; Inc, increase).*

affect the performance of MPAs and other resource governance regimes (Table 1). Context (age, geographic location), design (size, permitted uses), and management (zoning, boundaries, enforcement, and compliance) are likely to shape MPA outcomes (Ostrom 1990; McClanahan et al. 1997; Halpern & Warner 2002; Halpern 2003; Mascia 2004). In our sample, increases in food security were positively correlated with older (ANOVA; df=2; $F = 3.1467$; $p = 0.057$) and smaller (ANOVA; df=2; $F = 3.0591$; $p = 0.062$) MPAs. Ecological theory may largely explain this outcome because—all else being equal—one would expect older MPAs to build up fish biomass over time and smaller MPAs to experience higher rates of fish "spillover" into adjacent waters (National Research Council 2001). Both greater biomass and spillover should increase the likelihood of greater fish CPUE among fishers.

Contrary to expectations, other aspects of MPA context (i.e., tropical location), design (i.e., no-take designation, zoned uses), and management (i.e., formal enforcement, compliance rates, clearly defined boundaries) did not have observable effects on food security (Table 1). Although small sample sizes meant the power to detect significant effects of these factors was very low, the case material (e.g., Himes 2003) suggested that MPAs sometimes enhance food security for specific fishing subgroups by reallocating fishing rights and thereby reducing local competition for fishing resources (i.e., leaving a smaller number of fishers harvesting the same number of fish). Thus, on some occasions, the observed increase in food security appears to result at least partly from purely social dynamics (i.e., the reallocation of fishing rights) rather than an increase in fish biomass and spillover. In other cases, additional measures to mitigate destructive fishing pressures were established at the same time as MPAs (e.g., Galal et al. 2002; Abesamis 2006), complementing the MPA and perhaps having an ecological impact similar to prohibiting all extractive uses through a no-take designation. The case material (Goodridge et al. 1996; McClanahan & Mangi 2000; Roberts et al. 2001) also suggests that even MPAs with uncertain boundaries, limited formal enforcement, and considerable noncompliance can reshape socioecological dynamics in ways

Table 1. Fixed attributes, marine protected area (MPA) design variables, and MPA governance variables correlated with changes in food security and resource control among fishing groups and subgroups.*

	Food security		*Resource control*	
MPA attribute	n	*effect* (p)	n	*effect* (p)
Years since establishment	33	+ (0.057)	24	ns
Tropical/temperate	43	ns	27	ns
Size	32	− (0.062)	17	ns
No take	42	ns	24	ns
Zoning	40	ns	24	+ (0.002)
Clearly defined boundary	26	ns	15	ns
Formal enforcement	13	ns	17	ns
Compliance	20	ns	14	+ (0.007)

**Data analyzed using exact tests, except for years since establishment and MPA size (analysis of variance). Sample size (*n*), direction of correlative relationship (positive [+] or negative [−]), and statistically significant probabilities (*p*) are shown (ns, not significant).*

similar to a "functional" MPA, although perhaps in a less-dramatic fashion. Thus, even so-called paper parks may foster a degree of ecological recovery and a reallocation of access to fisheries resources that influence the food security of fishing groups and subgroups.

Changes in resource control were correlated with MPA zoning (exact test; $p = 0.002$) and high compliance (exact test; $p = 0.007$; Table 1). The subdivision of MPAs into zones allocated for different uses is one of the primary mechanisms through which fishing rights are defined and reshaped. Similarly, case material (e.g., Christie et al. 1994; Himes 2003) suggested that empowered fishing subgroups are more likely to comply with MPA regulations, whereas subgroups losing control over marine resources are more likely to break MPA rules. It is somewhat counterintuitive that no-take designation, clear boundaries, and formal enforcement – mechanisms for defining and institutionalizing resource rights – did not have a statistically observable relationship with shifts in resource control because the literature often associates these three factors with MPA zoning and compliance (e.g., National Research Council 2001). Moreover, although one might predict that older MPAs would be more likely to reshape resource rights (as MPAs become increasingly institutionalized over time), we did not observe any such effect. As one might expect, neither size nor location had an effect on resource control. In at least some cases, the absence of observed relationships may have resulted from the lower statistical power associated with small sample sizes.

Our findings complement those presented in the broader scientific literature on the social dimensions of MPAs. The manner in which MPAs shape the rights of resource users is not only an important indicator of social well-being, but may also influence stakeholder support for MPA development and management (e.g., Fiske 1992; Johannes 2002; Stoffle & Minnis 2008). Resource-dependent communities recognize the social and economic implications of new resource governance regimes like MPAs (Gelcich et al. 2005; Stoffle & Minnis 2008) and, as a result, may organize to protect or advance their diverse interests (e.g., income, food security, sense of place). Indeed, the impacts of MPAs on local fishers and other stakeholders may either catalyze or cripple efforts to expand existing MPAs and establish new sites (Fiske 1992; Woodley & Sary 2003). More generally, receptivity to and impacts of MPAs vary across social contexts and governance regimes (Pollnac et al. 2001; Cinner et al. 2005).

Conclusions

Our results highlight the multifaceted relationship between marine resource governance and human welfare. MPAs are neither uniformly good nor uniformly bad for coastal communities; rather, the social impacts of MPAs vary within and among groups and subgroups and across different indicators of social well-being (Mascia 2004; Mascia & Claus 2009). This suggests that MPAs may represent a viable strategy for enhancing food security and empowering local communities, but current MPA practices negatively affect at least a minority of fishers. Although our necessarily coarse categorization of study findings obscures the granular detail obtained through the case-study approach characteristic of most MPA research, our synthesis elucidates broader patterns obscured by a site-specific focus. Moreover, our results underscore the scarcity of rigorous research on the social impacts of MPAs, which necessitates caution when generalizing from our review.

To establish the foundation for more informed policy making, further research is essential to better document and explain variation in the positive and negative social impacts of MPAs. Qualitative and quantitative studies should closely examine the distributive impacts of MPAs within and among fishers and other stakeholder groups and explore the possibility of trade-offs among social outcomes (e.g., income vs food security; Mascia & Claus 2009). To facilitate comparisons across sites, measurement should include both contextually appropriate indicators and standard sets of indicators that are commonly recorded and widely recognized (e.g., indicators for U.N. Millennium Development Goals). Most importantly, researchers must examine not only the social impacts of MPAs, but also the sociopolitical and biophysical variables that shape these impacts (Mascia & Claus 2009; Sutherland et al. 2009). Once we have a sophisticated understanding of why some MPAs lead to social benefits and others have social costs, MPAs will be positioned to realize their full potential as a policy instrument for biodiversity conservation and poverty alleviation.

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Supporting Information

The site-specific MPA attributes, impacts, and data sources we used and the geographic distribution of these data are available as part of the online article (Appendix

S1). The authors are responsible for content and functionality of these materials. Queries (other than the absence of the material) should be directed to the corresponding author.

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