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Effectiveness of Marine Protected Areas in the Philippines for Biodiversity Conservation

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Abstract: *Quantifying the extent to which existing reserves meet conservation objectives and identifying gaps in coverage are vital to developing systematic protected-area networks. Despite widespread recognition of the Philippines as a global priority for marine conservation, limited work has been undertaken to evaluate the conservation effectiveness of existing marine protected areas (MPAs). Targets for MPA coverage in the Philippines have been specified in the 1998 Fisheries Code legislation, which calls for 15% of coastal municipal waters (within 15 km of the coastline) to be protected within no-take MPAs, and the Philippine Marine Sanctuary Strategy (2004), which aims to protect 10% of coral reef area in no-take MPAs by 2020. We used a newly compiled database of nearly 1000 MPAs to measure progress toward these targets. We evaluated conservation effectiveness of MPAs in two ways. First, we determined the degree to which marine bioregions and conservation priority areas are represented within existing MPAs. Second, we assessed the size and spacing patterns of reserves in terms of best-practice recommendations. We found that the current extent and distribution of MPAs does not adequately represent biodiversity. At present just 0.5% of municipal waters and 2.7–3.4% of coral reef area in the Philippines are protected in no-take MPAs. Moreover, 85% of no-take area is in just two sites; 90% of MPAs are <1 km^2. Nevertheless, distances between existing MPAs should ensure larval connectivity between them, providing opportunities to develop regional-scale MPA networks. Despite the considerable success of community-based approaches to MPA implementation in the Philippines, this strategy will not be sufficient to meet conservation targets, even under a best-case scenario for future MPA establishment. We recommend that implementation of community-based MPAs be supplemented by designation of additional large no-take areas specifically located to address conservation targets.*

Keywords: biodiversity, community-based marine conservation, coral reefs, gap analysis, marine protected areas, Philippines

Efectividad de las Áreas Marinas Protegidas en las Filipinas para la Conservación de Biodiversidad

Resumen: *La cuantificación de la medida en que las reservas cumplen con los objetivos de conservación y la identificación de discontinuidades en la cobertura son vitales para el desarrollo de redes sistemáticas de áreas protegidas. No obstante el amplio reconocimiento de las Filipinas como una prioridad global para la conservación marina, se ha realizado poco para evaluar la efectividad para la conservación de las áreas marinas protegidas (AMP) existentes. Las metas para la cobertura de AMP en las Filipinas fueron especificadas en la legislación Código de Pesquerías de 1998, que establece que 15% de las aguas costeras municipales (hasta 15 km de la línea de costa) debe ser protegida en AMP sin captura, y la Estrategia*

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Filipina de Santuarios Marinos (2004), que pretende proteger 10% del área de arrecifes de coral en AMP sin captura para 2020. Utilizamos una base de datos de cerca de 1000 AMP recién compilada para medir el progreso hacia esas metas. Evaluamos la efectividad de la conservación de las AMP de dos maneras. Primero, determinamos el nivel de representación de las bioregiones marinas y las áreas prioritarias en las AMP existentes. Segundo, evaluamos el tamaño y los patrones espaciales de las reservas en términos de las recomendaciones para las mejores prácticas. Encontramos que la extensión y distribución actual de las AMP no representa la biodiversidad adecuadamente. Actualmente, solo 0.5% de las aguas municipales y 2.7–3.4% de la superficie de arrecife de coral en las Filipinas está protegido en AMP sin captura. Más aun, 85% de la superficie sin captura está en solo dos sitios; 90% de las AMP tienen <1km^2. Sin embargo, las distancias entre las AMP existentes debería asegurar la conectividad larval entre ellas, proporcionando oportunidades para desarrollar redes de AMP a escala regional. No obstante el éxito considerable de los enfoques basados en comunidades para la implementación de AMP en las Filipinas, esta estrategia no será suficiente para alcanzar las metas de conservación, aun bajo el mejor escenario para el futuro del establecimiento de AMP. Recomendamos que la implementación de AMP basadas en comunidades sea suplementada con la designación de áreas extensas de no captura adicionales localizadas específicamente para atender las metas de conservación.

Palabras Clave: análisis de discontinuidades, áreas marinas protegidas, arrecifes de coral, biodiversidad, conservación marina basada en la comunidad, Filipinas

Introduction

The Philippines is widely recognized as a global priority for marine conservation (Roberts et al. 2002*b*; Carpenter 2005). Located within the highly diverse coral triangle, the Philippine archipelago has more than 1700 reef fish species (Carpenter 2005) and an estimated 9% of global coral reef area (approximately 25,060 km^2) (Spalding et al. 2001). Despite overwhelming pressures on the marine resources (White et al. 2000; Burke et al. 2002; Roberts et al. 2002*b*), the Philippines has emerged as a well-documented success story for marine protected area (MPA) implementation, largely due to the success of community-based approaches to management (Christie et al. 2002; Alcala & Russ 2006).

Quantifying the extent to which existing reserves meet conservation objectives and identifying gaps in coverage are vital to developing systematic protected area networks (Margules & Pressey 2000; Lourie & Vincent 2004). Although establishing comprehensive, ecologically representative, and connected networks of MPAs is the key objective of conservation strategy in the coral triangle (Coral Triangle Initiative 2008), a systematic assessment of the effectiveness of existing MPAs has yet to be undertaken for much of the region, including the Philippines.

Previous attempts to assess the effectiveness of MPAs in the Philippines have focused on the fisheries benefits of individual reserves. Empirical studies demonstrate positive effects of these types of reserves on the density and biomass of target and nontarget species within MPA boundaries and in adjacent fished areas (Russ et al. 2004; Alcala et al. 2005; Abesamis et al. 2006). Frameworks have also been developed to evaluate the management effectiveness of individual MPAs (White et al. 2006*b*). Nevertheless, there has been no systematic assessment of the effectiveness of MPAs at larger spatial scales or of conservation objectives specifically.

Although the fisheries objectives of MPAs are concerned with sustaining populations of target species and enhancing surrounding fisheries (Sale et al. 2005), conservation objectives emphasize the representation of biodiversity features (Margules & Pressey 2000; Day et al. 2002) and design criteria that promote persistence of those features (e.g., minimum reserve size, spacing between no-take areas). Targets for MPA coverage in the Philippines have been specified in the 1998 Fisheries Code legislation, which calls for 15% of coastal municipal waters (within 15 km of the coastline) to be protected within no-take MPAs, and in the Philippine Marine Sanctuary Strategy (Areco et al. 2004), which aims to protect 10% of coral reef area in no-take MPAs by 2020.

Using the most comprehensive MPA database compiled to date, we measured progress made toward these conservation targets by assessing the extent, conservation effectiveness, and gaps in coverage of Philippine MPAs. We evaluated conservation effectiveness in two ways. First, we determined the degree to which marine bioregions and conservation priority areas are represented within existing MPAs. Second, we assessed size and spacing patterns of reserves in terms of recommendations derived from current knowledge about larval dispersal distances. Finally, we assessed the feasibility of meeting conservation targets under a best-case scenario for MPA implementation.

Methods

MPA Database

We requested spatial and descriptive data for MPAs from NGOs (nongovernmental organizations) and academic institutions in the Philippines, global protected area databases (World Database on Protected Areas [UNEP

WCMC 2007], MPA Global [Wood 2007]), and peer-reviewed and gray literature. We compiled these data into a new geodatabase of Philippine MPAs with ArcGIS (version 9.2; ESRI, Redlands, California). We removed duplicate records, combined records that were distinct zones within a single protected area (e.g., core and buffer zones), and used the remaining 985 MPAs in our analyses. We split MPAs into two categories on the basis of their governance. Community-based MPAs were those designated under local or municipal level ordinances and governed by community organizations with or without assistance from local government units (White et al. 2006*a*). Nationally designated sites were those designated under the National Integrated Protected Areas System (NIPAS) Act (1992) or Ramsar Convention or declared as World Heritage Sites under the United Nations Educational, Scientific, and Cultural Organization (UNESCO) legislation and governed primarily by a national government agency.

Many database records were incomplete, with missing data values for one or more data fields. Rather than excluding sites without all spatial information ($n = 385$), which would have resulted in an underestimate of MPA extent, we substituted incomplete records of MPA size with median values for that MPA type (nationally designated = 64.57 km^2, community-based = 0.12 km^2). Geographical coordinates were available for 43% of sites; the location of other sites was only available to municipality (56%) or provincial (1%) level. We estimated the locations for these sites using a gazetteer.

Conservation Effectiveness

A gap analysis provides a framework for assessing the extent to which biodiversity features are represented within a protected-area network (Jennings 2000). We used this approach to determine how well existing MPAs in the Philippines represent marine bioregions, conservation priority areas, and marine corridors identified by the Philippine Biodiversity Conservation Priority-Setting Program (Ong et al. 2002). Six marine bioregions, 35 integrated priority areas, and nine marine biodiversity corridors were identified through a series of expert workshops. Bioregion delineation was determined on the basis of the geology of the Philippine archipelago and extant reef fish assemblages. Priority areas were identified on the basis of biogeographic representativeness, ecosystem diversity, ecosystem function, threat status, species richness, and endemism. Areas identified as priorities for 11 taxonomic groups (cetaceans, dugongs, seagrasses, seaweed, corals, mangroves, molluscs, reef fishes, turtles, elasmobranchs, and whale sharks) were integrated and classified into extremely high ($n = 13$), very high ($n = 12$), and high ($n = 10$) priorities. Marine biodiversity corridors were identified as the areas of importance for connectivity between bioregions (Ong et al. 2002).

We overlaid polygon feature layers for the bioregions, priority areas, and corridors with a point-feature shapefile of the locations of MPAs. To quantify the degree to which each feature was represented by existing MPAs, we identified MPAs occurring within each feature polygon and summed their area and no-take area from the MPA attribute table. We determined levels of representation as the percentage of the area of each biodiversity feature within MPAs.

In addition to quantifying current levels of representation, we estimated whether existing MPAs represent biodiversity better than would be expected by chance. We compared the observed number and area of MPAs occurring in each bioregion with the expected number on the basis of the null hypothesis that the distribution of MPAs is proportional to the area of municipal waters in each bioregion. We also compared the number of MPAs within priority regions with the mean number occurring within 100 random distributions generated with Hawth's Analysis random points tool for ArcGIS (Beyer 2004).

We used a size–frequency distribution to identify the proportion of MPAs that meet minimum size requirements on the basis of recommendations in the literature. We then performed a simple analysis of connectivity between MPAs by calculating the Euclidean distance to the nearest MPA for each site. The observed inter-MPA distances were compared with recommendations for MPA network design taken from Shanks (2003) and Jones et al. (2008).

Feasibility of Attaining Conservation Targets

We assessed the feasibility of meeting MPA coverage targets under a best-case scenario of one no-take MPA designated for every coastal *barangay* (the smallest political unit within a city or municipal government). Although optimistic, this scenario is theoretically viable given that at least four municipalities have achieved this target. Annual growth rates of MPA implementation used to predict target attainment dates were assumed to be the maximum historical rate (97 MPAs per year in 2002). The future MPAs were assumed to be the current median size of community-based MPAs and to be located on coral reefs.

Results

MPA Extent

As of 2008 at least 985 MPAs had been established in the Philippines (Fig. 1), and they covered approximately 14,943 km^2. Of these, 942 MPAs had a no-take component, with a combined no-take area of 1459 km^2. Thus, 4.9% of coastal municipal waters (within 15 km of the coastline) were protected within MPAs, with 0.5% within no-take areas. Estimates of coral reef area in the

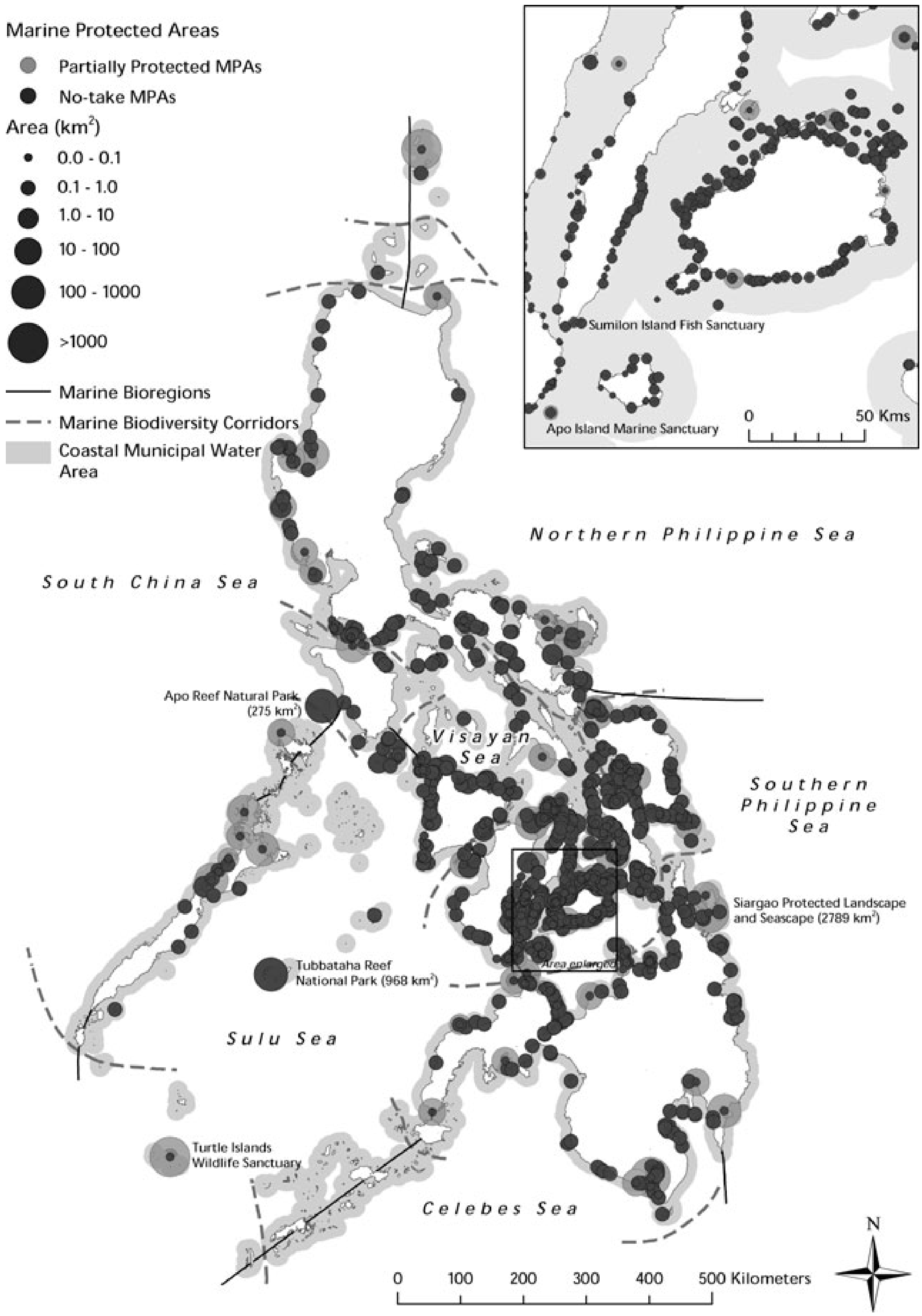

Figure 1. Distribution of marine protected areas (MPAs) throughout the Philippines (marine bioregions and corridors identified by Ong et al. [2002]). The enlarged area shows the highest concentration of MPAs in the Visayan Sea bioregion. The MPAs with the largest no-take areas are Tubbataha Reef National Park and Apo Reef Natural Park. Siargao Protected Landscape and Seascape is the largest individual MPA, although some forms of fishing are allowed in much of its area. The Turtle Islands Wildlife Sanctuary is the most isolated MPA.

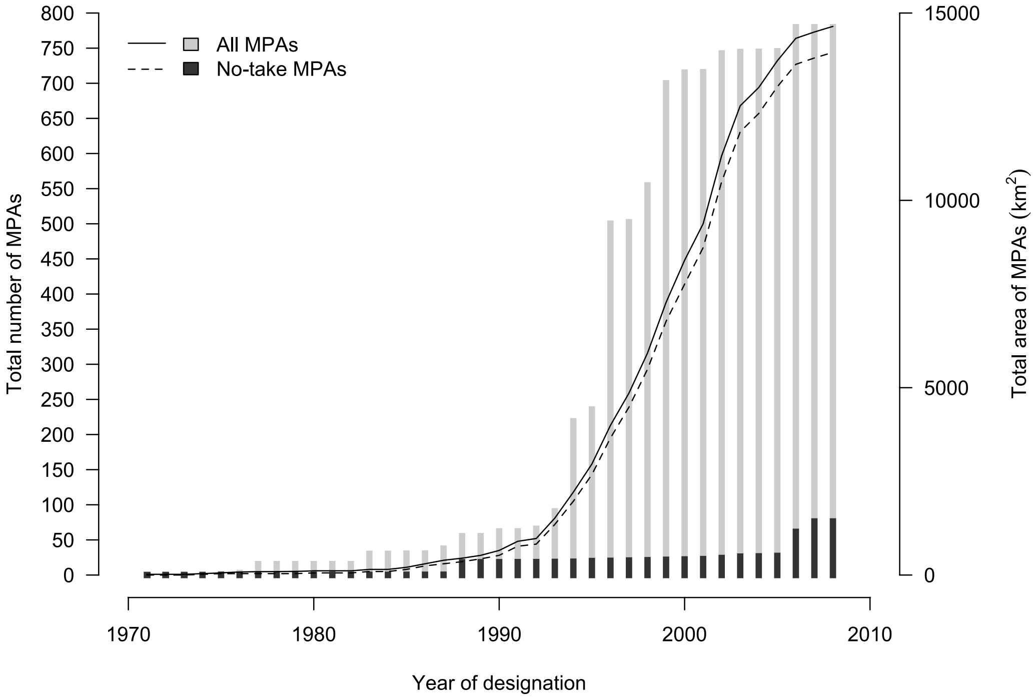

Figure 2. Cumulative growth in the number (lines) and area (bars) of marine protected areas (MPAs) in the Philippines between 1970 and 2008. Only MPAs with data available for year of designation are plotted ($n = 527$).

Philippines varied between 20,000 km^2 (A.C.A, personal communication) and 26,000 km^2 (Burke et al. 2002). Accounting for this potential range, we estimated that between 2.7% and 3.4% of coral reef area in the Philippines is protected within no-take MPAs. Community-based MPAs comprised 95% of records in our database, with a combined estimated area of 628 km^2 and no-take area of 206 km^2.

There was an almost-exponential increase in the number and area of MPAs in the Philippines following passage of the Local Government Code in 1991 (Fig. 2). Almost 50% of current MPAs were established before the Fisheries Code of 1998, which set the target of 15% of coastal municipal waters within no-take MPAs. The increase in area of no-take MPAs has been more modest, with notable increases in 1983, 1988, and 2007 with the declaration and expansion of two large no-take MPAs, Tubbataha Reef National Park (968 km^2) and Apo Reef Natural Park (275 km^2) (Fig. 2). Growth in the number and area of MPAs slowed after 2002. We believe, however, this is due to a time lag between MPA implementation and appearance in databases, rather than a real decline in the number of sites being designated (Fig. 2).

Representation of Bioregions, Priority Areas, and Corridors

The number and extent of MPAs varied among different marine bioregions (number: $\chi^2 = 368.90$, df=5, $p < 0.001$, extent: $\chi^2 = 2641.46$, df=5, $p < 0.001$). The Visayan Sea bioregion had 67% of all MPAs, 2.5 times more than expected on the basis of its municipal water area (Fig. 1, Table 1). The Sulu Sea bioregion had nearly three times fewer MPAs than expected. Nevertheless, in terms of the total area of MPAs, the Sulu Sea and South China Sea bioregions were best protected, with 1.25% and 0.66% of their municipal water area within no-take MPAs, respectively (Table 1). These bioregions contained the large no-take areas of Tubbataha Reef National Park and Apo Reef Natural Park, respectively (Fig. 1). The high number of MPAs in the Visayan Sea did not result in a large area protected; only 1.50% of municipal waters were within MPAs and 0.17% were within no-take MPAs (Table 1). No-take area of individual MPAs did not differ significantly among bioregions (Kruskal–Wallis, $\chi^2 = 3.47$, df=5, $p = 0.6285$).

Distance to the nearest neighbor for existing MPAs was significantly smaller than expected from the random distributions of MPAs (nearest neighbor ratio $= 0.314$, $p < 0.001$, and bootstrapped p value from 10,000 iterations). Philippine MPAs were clustered in the southern area of the Visayan Sea bioregion (Fig. 1).

Representation of marine conservation priority areas within no-take MPAs varied between 0% and 48%. The Tubbataha Reef priority area was best represented, with 48% coverage within a single large no-take MPA. Two very high-priority regions (Balabac Island and Cuyo Islands) did not contain any MPAs. Marine corridors were not well represented by current MPAs; four of the nine corridors did not contain any MPAs. At best, the Mindoro Calavite

Table 1. Representation of marine bioregions within Philippine marine protected areas (MPAs).

Marine bioregion[a]	*Number of MPAs*	*MPA coverage (km^2)*		*Municipal waters*[b] *protected (%)*	
		all	*no take*	*all*	*no take*
Celebes Sea	50	2345.13	7.37	6.77	0.02
Northern Philippine Sea	35	2469.60	7.54	6.52	0.02
South China Sea	51	1836.93	283.71	4.26	0.66
Southern Philippine Sea	102	3500.02	33.16	12.67	0.12
Sulu Sea	90	3573.35	991.29	4.52	1.25
Visayan Sea	663	1219.50	136.50	1.50	0.17

[a]*Marine bioregions taken from Ong et. al. (2002).*
[b]*Municipal water boundaries (15 km offshore) were calculated following DENR (2001).*

Tablas Triangle had 1.24% of its area inside no-take MPAs.

Marine protected areas represented priority areas for marine conservation better than expected if they were placed randomly (t test, $t = -5.2797$, df=99, $p < 0.001$). More than 50% of total MPA area and 70% of total no-take area was within extremely high priority regions. This result was due, however, to the location of the largest no-take area in the Philippines (Tubbataha Reef MPA) being in an extremely high priority region.

Size and Spacing of Individual MPAs

The size of MPAs ranged from 0.01 km^2 to 2789.14 km^2 (Siargao Protected Landscape and Seascape, Fig. 1) (mean 23.60 km^2 and median 0.15 km^2, $n = 604$) (Fig. 3). The no-take area of MPAs ranged from 0.01 km^2 to 968.28 km^2 (mean 2.48 km^2 and median 0.12 km^2, $n = 571$). The substantial difference between mean and median no-take area was due to the disproportionate contribution of the two largest no-take MPAs, Tubbataha Reef National Park (968.28 km^2) and Apo Reef Natural Park (274.69 km^2) (Fig. 1). These two MPAs have >85% of the total extent of no-take area in the Philippines. Ninety percent of all MPAs for which spatial data were available had a total area of <1 km^2, with the most common size class between 0.1 and 0.5 km^2 (Fig. 3).

We found that MPAs were well spaced and thus potentially well connected, with 94% of MPAs within 1–20 km of at least one other reserve and more than 70% of MPAs within 5 km of another reserve (Fig. 4).

Feasibility of Attaining Targets

Under a scenario of one MPA designated per coastal *barangay,* at the current median size of community-based MPAs (0.12 km^2), only 0.3% of coastal municipal waters, or 7.28% of coral reef area, would be protected

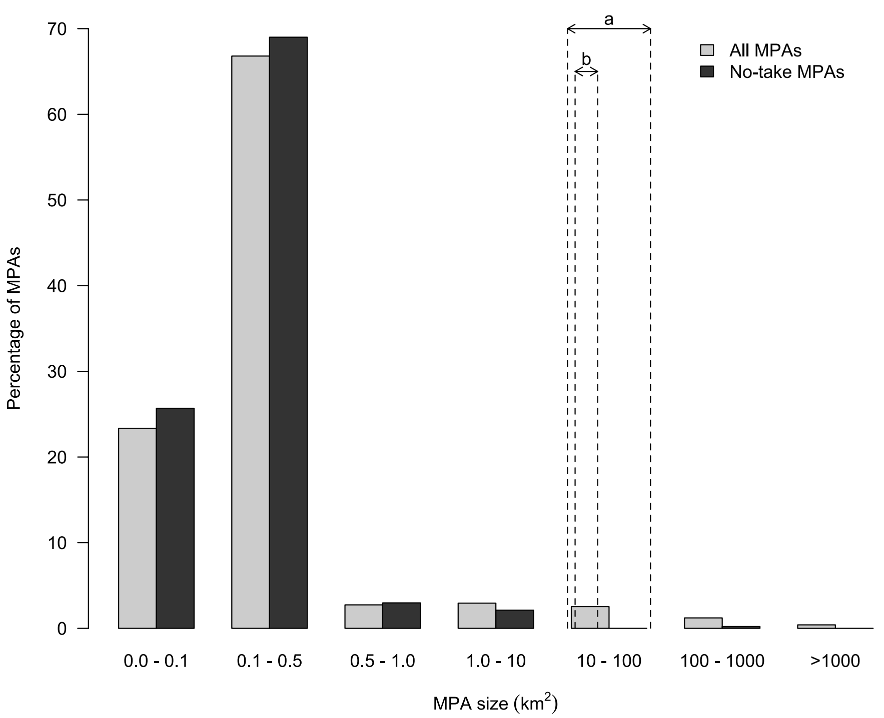

Figure 3. Size-frequency distribution of all marine protected areas (MPAs) (light bars, n = *600) and MPAs with no-take area (dark bars,* n = *567) for which spatial data were available, showing recommended MPA size on the basis of predicted distance of larval dispersal: (a) 10–100 km^2 (Halpern & Warner 2003) and (b) 12.5–28.5 km^2 (Shanks 2003).*

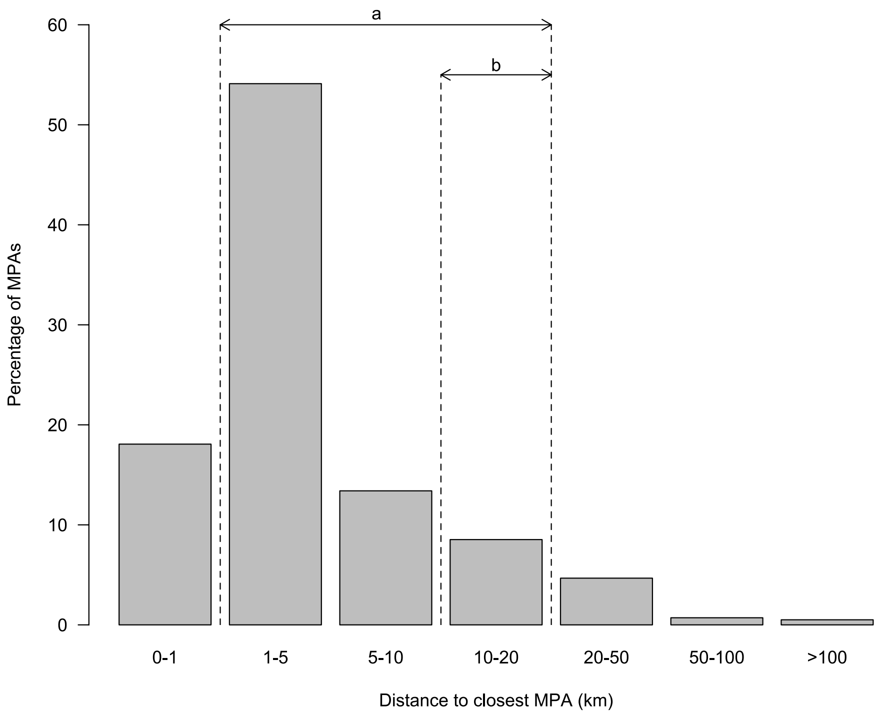

Figure 4. Frequency of distance to the nearest marine protected area (MPA), showing recommended distances between MPAs in a network designed on the basis of predicted larval dispersal distances taken from (a) Jones et al. (2008) and (b) Shanks (2003). All locations are estimated to be accurate to within 5 km. Euclidean distance between MPAs was measured with the Hawth's analysis distance between points (Beyer 2004) extension for ArcGIS.

in no-take MPAs (Table 2). This fails to achieve Fisheries Code or Philippine Marine Sanctuary Strategy targets. To achieve the Philippine Marine Sanctuary Strategy target of 10% of coral reef area in no-take MPAs, an additional 2030 km^2 of coral reef no-take area is required. If one community-based no-take MPA were established per coastal *barangay*, an increase in the size of no-take MPAs to 0.31 km^2 would be required (Table 2), which is almost three times larger than the current median size. If the maximum historical rate of MPA implementation (97 MPAs per year in 2002) were to continue, this target would not be reached until 2076. To meet the target by 2020 would require the designation of at least 545 MPAs ($\geq$0.31 km^2) every year.

Table 2. Percentage of target area protected under different no-take marine-protected-area (MPA) scenarios.

Scenario[a]	*Municipal waters (%)*	*1 km offshore (%)*	*Reef area*[b] *(%)*
Current	0.48	5.02	1.89[c]
Current, plus 1 MPA/coastal barangay (0.12 km^2)	0.27	2.78	7.28
Current, plus 1 MPA/coastal barangay (0.31 km^2)	1.19	12.2	10.24

[a] *A barangay is the smallest political unit within a city or municipal government.*
[b] *Reef area estimate taken from Spalding et al. (2001).*
[c] *Accounts for the reef area only in Tubbataha Reef and Apo Reef MPAs.*

Discussion

Our results provide the first comprehensive national-scale assessment of the conservation effectiveness of MPAs in the Philippines. Results indicate that the current extent, distribution, and size of MPAs are inadequate to fulfill conservation objectives at this scale. Although individual MPAs can achieve local-scale fisheries objectives (e.g., Alcala & Russ 2006), they do not constitute a comprehensive national MPA network that is needed to achieve an adequate representation of biodiversity.

We estimated that 0.5% of coastal municipal waters and between 2.7% and 3.4% of coral reef area in the Philippines are currently protected within no-take MPAs. This falls well short of legislated targets. Although there is some uncertainty in our estimate of the extent of MPA coverage as a result of sites with missing spatial information, this is unlikely to alter our results significantly. Assigning minimum (0.01 km^2), median (0.12 km^2), or mean (0.28 km^2) values to sites with missing size data resulted in a maximum difference in estimates of 63 km^2 of no-take area. This difference is <0.1% of coastal municipal waters and 0.5% of coral reef area.

As with many percentage-based targets (Agardy et al. 2003; Rodrigues et al. 2004), little information is available on how the target of 15% of coastal municipal waters in no-take MPAs (1998 Fisheries Code) was determined. The process was likely one of political convenience rather than scientific endeavor. Given that 15% of Philippine municipal waters are about twice the total coral reef area in the country, it does not appear to be an achievable or appropriate goal. Without more specific guidance as to how biodiversity should be protected (e.g., proportional representation of habitat types), it would be possible to fulfill the legislated requirements by establishing MPAs exclusively between 10 km and 15 km offshore, but such an action would not protect the coral reef ecosystems that are most at threat from overexploitation.

The Philippine Marine Sanctuary Strategy target was agreed upon through a series of expert workshops (P.M. Alino, personal communication) and has a more solid scientific basis. This target was adopted in the Draft National Plan of Action of the Philippines under the Coral Triangle Initiative. Nevertheless, the target of protecting 10% of reef area falls short of general recommendations that a minimum of 20% and an optimum of 30%–50% of area be set aside in marine reserves (Roberts et al. 2002*a*; Airame et al. 2003; Jones et al. 2008).

The distribution of MPAs in the Philippines is not representative of marine biodiversity. The Sulu Sea bioregion and marine biodiversity corridors, in particular, are poorly represented. The pronounced bias in the distribution of MPAs toward the Visayan Sea reflects the history of community-based management efforts, which originated at Sumilon and Apo islands (Alcala & Russ 2006) and the locations of NGOs and academic institutions that continue to facilitate the establishment of MPAs in that region (Pollnac et al. 2001; White et al. 2002, 2006*b*). Although representation of bioregions does not confer protection of features and processes occurring within them, biogeographic classifications such as these provide a useful framework for the assessment of protected-area representativeness where fine-scale distribution data are unavailable (Day et al. 2002; Lourie & Vincent 2004).

Areas identified as the highest priorities for marine conservation contained more MPAs than expected by chance. This suggests that the distribution of MPAs may be targeted toward areas of conservation importance. Nevertheless, caution should be taken when interpreting this result. Prioritizations undertaken by expert working groups are liable to spatial and taxonomic bias toward areas of expertise of the participants. It is possible that the delineation of priority areas was influenced by the availability of biodiversity data, which is typically greatest in regions with many MPAs. As such, it may be the case that the location of priority areas reflects the distribution of MPAs, rather than vice versa.

The size and spacing of MPAs should be varied to account for natural variation in larval dispersal distances (Halpern & Warner 2003; Roberts et al. 2003; Jones et al. 2008). Our results indicate that Philippine MPAs do not conform to this pattern. No fully protected MPAs were of intermediate size (10–100 km^2) as recommended by Halpern & Warner (2003), and only two no-take MPAs exceeded this size. The median no-take area of Philippine MPAs is just 0.12 km^2, compared with 6 km^2 in Latin America and the Caribbean (Guarderas et al. 2008) and 4.6 km^2 globally (Wood et al. 2008). Recent evidence suggests that local retention of larvae is more common than previously thought (Almany et al. 2007; Planes et al. 2009), which indicates that even small MPAs provide some recruitment benefits within and close to their boundaries (Planes et al. 2009). Nevertheless, such small MPAs are unlikely to provide protection for larger, more mobile species (Sale et al. 2005) and contribute little toward achieving regional conservation objectives, which are typically stated as percent area targets.

Typically, Philippine MPAs are spaced 1–5 km apart, distances that are likely to promote larval connectivity (Shanks 2003; Jones et al. 2008). Connectivity is not determined by distance alone, however, and larval dispersal models that account for the direction and strength of water movement and species' larval characteristics would be required to better predict connectivity between MPAs (Planes et al. 2009).

Ninety-five percent of MPAs in our database were community based. Although community-based MPAs have been widely proposed as a fisheries management tool that is compatible with biodiversity conservation objectives (Alcala & Russ 2006; Christie & White 2007), their contribution toward achieving conservation targets has often been overlooked because of their small size and poor levels of documentation. Previous attempts to assess the effectiveness of protected-area networks have excluded sites that did not meet criteria on the basis of minimum size or data availability. For example, Mora et al. (2006) excluded many MPAs because of their small size or lack of recognition by national governments. Rodrigues et al. (2004) only considered protected areas >1 km^2; application of this criterion would have excluded 93% of the MPAs in our database. Such criteria clearly underestimate the number and extent of MPAs in regions where community-based management prevails. The MPA Global Database (Wood 2007) currently lists 202 MPAs in the Philippines, just 20% of the sites we considered.

Community-based MPAs constitute most of the number, but not the area of the MPAs in the Philippines. The future projections derived from a best-case scenario indicated that even if adopted throughout the Philippines, community-based MPAs would not be sufficient to fulfill conservation targets without a significant increase in their size. Nevertheless, in the context of the Philippines, widespread increases in the no-take area of MPAs are unlikely because of socioeconomic constraints imposed by the high dependence of local communities on marine resources and low spatial mobility of fishers.

The inability to meet conservation targets with community-based MPAs alone highlights the importance of large no-take areas such a Tubbataha Reef National Park and Apo Reef Natural Park. Together these two sites comprise more than 85% of the total no-take area of MPAs in the Philippines. Nevertheless, much of this area is a buffer zone in open sea, and as such does not contain coral reef. Ensuring the continued protection of these large no-take MPAs should be a high priority. Larger and more remote sites present a greater enforcement challenge (White & Palaganas 1991), but if managed well, funds generated through tourism can contribute toward costs (Tongson & Dygico 2004).

Most of the large MPAs in the Philippines allow extractive activities within their boundaries. Thus, they provide little protection to marine biodiversity. They do, however, offer an existing commitment to the management of marine resources. Opportunities may exist to increase the conservation value of these sites, either through designating their entire area as no-take (Apo Reef Natural Park was established in 1996, but only became fully no-take in 2007) or by establishing core no-take zones within them. This approach may be more expedient than identifying new sites for large no-take MPAs.

The number and area of MPAs can be misleading indicators of conservation effectiveness if MPAs are not well managed and enforced (McClanahan 1999; Chape et al. 2005; Mora et al. 2006). Globally, MPA management effectiveness is low (Kelleher et al. 1995), and many MPAs fail to meet their management objectives (Jameson 2002). Fisheries benefits of MPAs in the Philippines are conditional on good levels of enforcement and compliance (Alcala & Russ 2006; Samoilys et al. 2007). The same is likely to be true for conservation benefits. Estimates of the proportion of existing MPAs that are well managed and enforced were made with data from the Marine Protected Area Rating System (White et al. 2006*b*). Of the 251 MPAs surveyed, just 12% are rated as "sustained," which means they have a fully operational enforcement system, management plan, and monitoring program. A further 35% are rated as "enforced." If these figures are accurate, our results are optimistic assessments of conservation effectiveness.

A major challenge to quantifying the extent of any protected-area system is the dynamic nature of the network itself and of the data available about it (Mora et al. 2006). The MPA database we compiled is the most comprehensive to date for the Philippines. There are likely to be more MPAs, however, for which data were unavailable. Ongoing efforts to collect and verify data for existing and newly designated MPAs will likely result in the revised estimates of coverage and extent and will allow more comprehensive assessments of their effectiveness.

Conclusions

Our results indicate an urgent need to expand the area within no-take MPAs in the Philippines. This should be done strategically, to address biases in the representation of bioregions and target priority areas for marine conservation. The development of systematic, regional-scale networks of MPAs that address both fisheries sustainability and biodiversity conservation objectives should be a priority. To better satisfy conservation objectives, we recommend that the Philippines work on three things to improve MPA implementation and effectiveness. First, continue efforts to increase the number and, where possible, size of community-based MPAs. Second, designate additional large no-take areas specifically to address conservation goals. Finally, continue to build capacity of both local government-supported MPAs and national agency-managed MPAs to improve overall management effectiveness and governance of individual sites.

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