



Governance and effects of marine reserves in the Gulf of California, Mexico

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ABSTRACT

We trace the evolution, governance, and effects of three marine reserve (no-take zones) initiatives in the Gulf of California, Mexico: Loreto Bay National Park, Puerto Peñasco, and San Pedro Mártir Island Biosphere Reserve. Preliminary monitoring results, although highly variable, are encouraging for conservation and fisheries management. However, open access situations and differing conceptions among local stakeholders and government concerning access rights to fishing grounds, coupled with limited support for surveillance and lags between local and government institutional arrangements and interests, are the main constraints for the success of these and future reserves in the region. We discuss the main social–ecological feedbacks at play and the implications of our findings within a regional context.

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1. Introduction

Since the 1980s, management and conservation of marine resources has seen a global movement towards “local” governance and empowerment, making community-based management and co-management a top priority in non-governmental conservation organizations’ and at times government agencies’ environmental agendas. Coupled to the rise in the transferability of management responsibilities these strategies entail, the 1990s saw a marked advocacy for the use of marine protected areas (MPAs) in the form of marine reserves or “no-take zones” (areas fully protected from fishing) as fishery management tools [1,2]. This came in response to the frustration over the evident failure of many traditional “top-down” and single species management practices [3] and the need to implement strategies for protecting and/or enhancing harvestable stocks while promoting marine conservation [1,2,4].

Although the coupled establishment of marine reserves and locally-based governance structures is promising as a conservation and development tool, insufficient research has been conducted to assess the conditions that may lead to successful implementation

and the effects of marine reserves on the resilience of social and ecological systems. This requires an analysis of the evolution of cooperative management efforts leading to the establishment of reserves in cases where we trace the outcomes of these efforts both from a social as well as bio-physical perspective. The Gulf of California, Mexico, offers a unique setting to do so, given current and past efforts by the Mexican Government and local communities to establish forms of MPAs [5] and Mexico’s challenges as it embarks on setting its agendas for coastal and ocean management [6].

We present and discuss some of the preliminary outcomes of three emerging efforts to establish marine reserves (no-take zones) in the Gulf of California. These efforts are in three areas: Loreto Bay National Park, Puerto Peñasco, and San Pedro Mártir Island Biosphere Reserve (herein LBNP, PP, and SPMI). These different cases were established and operated under various degrees of local involvement and governance. In all three cases, the involvement of fishers and the participation of conservation NGO’s has been integral for the creation and governance of the reserves. Fishers have petitioned their establishment (PP, LBNP), were key actors in designing the zoning of the reserves (LBNP, SPMI, PP) and have taken a leadership role in the ecological monitoring process (PP, SPMI).

The purpose of this paper is three-fold. First, we trace the evolution of these management and conservation efforts. Second, we shed light on the institutional and ecological feedbacks governing their outcomes and discuss the implications of our

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findings within a regional context. Third, we provide recommendations for future use and implementation of marine reserves in the Gulf of California. Our analysis is based on our collective personal experiences, having been involved in these marine reserves as academic advisors and non-governmental organization (NGO) practitioners and researchers since their inception and/or during important phases of zoning and implementation. Our involvement in these efforts has led to over 200 days of underwater surveys, participation in more than 50 meetings with the fishing sector, and semi-structured and structured interviews with over 150 people including fishers, government officials, and NGO representatives.

2. The physical setting: the Gulf of California and its fisheries

Apart from being the only sea that may be considered “the exclusive property” of a single nation [7], the Gulf of California or Sea of Cortés (herein “the Gulf”) is unusual in a global perspective. In a relatively small area, it embraces an array of marine environments, from deep-water trenches and coastal and island rocky reefs to the sandy and shallow waters of the Colorado River delta. It also constitutes one of the most productive seas in the world [8]. Fed by constant tidal and wind-driven upwelling systems, tidal currents, and variations in sea surface temperature, the productive machinery of the Gulf allows a large accumulation of biomass on a year-round basis [9]. This sea provides 70% of Mexico’s National fisheries’ value [10] and a fishing industry that has molded the communities surrounding the Gulf and crafted most of the complex social–ecological feedbacks of this region.

The development of fisheries in the Gulf has been immersed in a complex political ecology from its onset [11]. Although subsistence fishing has existed for millennia among the various indigenous peoples living in the region [12,13], commercial fishing did not come into play until the 1920s and 1930s [14] following Mexico’s Revolution and President Cárdenas’ appropriation politics and institutionalization of fishing cooperatives [11]. In recent decades, fishing in the Gulf has changed dramatically both in terms of production of fishery resources and diversity of species harvested as well as in the evolution of territorial conflicts, institutional arrangements, and increasing presence and interest of conservation NGOs working in the region since the early 1990s.

Possibly no other fishing sector has seen such a rate of development and change as the small-scale fishing sector. In the past 50 years, small-scale fishing has changed from being a relatively low-impact and mono-specific endeavor – targeting a handful of commercial species primarily for the domestic market – to a multi-specific and, collectively, highly impacting (ecologically and economically) activity [15–17]. Depending on the season, anywhere between 10,000 and 24,000 small-scale fishing boats operate in the Gulf on a daily basis and target over 70 different species of fish and shellfish, much of which is destined for the international market in the US and Asia [10,15].

From the political and economic arena, the rapid development of fisheries in the Gulf has been fueled by waves of national and international market demands, regional markets propelled by tourism growth, maximization and development government policies [11], and the existence of increasingly weak fisheries management institutions. From an ecological perspective, the overall productivity of the Gulf has attracted fishers from various parts of Mexico in wave cycles [15]. However, the brief history of commercial fishing in the Gulf has already experienced a boom-and-bust pattern of various fisheries, with evidence pointing towards an overall decline in ecological complexity and a tendency to fish down marine food webs [18,19].

3. Fishery decline, conservation agendas, and the emergence of MPAs

Given the state of Mexico’s fishery resources, the National Institute of Fisheries (*Instituto Nacional de la Pesca y Acuicultura*, INAPESCA), the scientific backbone of Mexico’s fishery management agency, has declared that 60% of fisheries in Mexico are being exploited to their capacity or overexploited, and therefore has advised to stop issuing new fishing permits for most fisheries [20]. However, corruption and inefficiency within the fishery sector and the government, as well as growing immigration rates to the coast, has managed to overturn precautionary regulations. The result is that many fisheries in the Gulf have operated in near open access conditions and have seen a marked decline in catch per unit of effort (CPUE) or in total production over their short history [21]. This has given rise to an increase in territorial conflicts among fishers, displacement of fishers to search for productive areas farther away from their home ports, and as one solution the emergence of community-based efforts aimed at controlling access to fisheries and better management of local fishery resources [see 22,23]. In addition, the rapid increase and influence of conservation NGOs since the 1990s, as well as Mexico’s commitments for environmental compliance as part of the North American Free Trade Agreement and other international biodiversity conservation agreements [24] has brought about pressure for the adoption of biodiversity conservation interests in fisheries management and the implementation of various co-management practices.

Parallel to downward trends in catch in the fishing industry, the administration of fisheries at a national level has also gone through dramatic changes. In the past two decades, the management body for fisheries in Mexico has shifted from being a Federal Secretariat solely devoted to fisheries (*Secretaría de Pesca*) to a subsecretariat of the Secretariat of the Environment, Natural Resources, and Fisheries (SEMARNAP) and, currently, a National Commission (*Comisión Nacional de Acuicultura y Pesca*, CONAPESCA) managed independently of environmental issues under the Secretariat of Agriculture created during President Fox’s administration (*Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación*, SAGARPA). These changes have occurred with the subsequent budget and personnel reductions as well as diminishing authority and weight in national government policies [25].

It is within this political and ecological setting that the emergence of MPAs as management and conservation tools has taken place in the Gulf [5,6]. Managed under the recently created National Commission of Protected Natural Areas (*Comisión Nacional de Áreas Naturales Protegidas*, CONANP), there are currently 11 MPAs in the Gulf. These fall into three general management categories: National Parks, Zones for Protection of Flora and Fauna, and Biosphere Reserves. In addition to the inception of such protected areas, Mexico’s National Institute of Ecology, together with prominent Mexican and international academic institutions and conservation NGOs, recently started crafting priorities for conservation [see 5,26] and for the establishment of a network of marine reserves in the Gulf [see 27].

Although attempts at using MPAs as management tools in the Gulf began in 1993 with the creation of the Upper Gulf of California and Colorado River Delta Biosphere Reserve – primarily for the protection of the endangered and endemic large croaker *totoaba* (*Totoaba macdonaldi*) and the vaquita porpoise (*Phocoena sinus*) – it is only since 2000 that efforts have focused specifically on defining fully protected (no-take) marine reserves as a means to manage and enhance small-scale fisheries while conserving marine ecosystems. The oldest of these reserve initiatives are located in the Loreto Bay National Park (LBNP) – adjacent to the

Baja California Peninsula – Puerto Peñasco – in the upper northern Gulf (PP) – and San Pedro Mártir Island (SPMI) – in the midriff island region – (Fig. 1). Following we describe the evolution of these initiatives and their preliminary outcomes.

4. Loreto Bay National Park

The Loreto Bay National Park (LBNP) is located adjacent to the east coast of central Baja California Peninsula in the northern portion of the state of Baja California Sur. It covers an area of 206,580 ha (2065 km²), including a large marine portion (~1840 km², 89% of the park's total area) and five islands adjacent to the city of Loreto, a fishing and tourism community of ca. 10,000 people (Fig. 2). Six other small fishing communities are found within the park's boundaries, and approximately 330 small-scale fishers make use of the park [28].

The park encompasses numerous marine environments such as rocky reefs, silt and sand seabeds, algal prairies, calcareous algae (rodolith) beds, small mangrove estuaries, and pelagic waters. It harbors more than 700 species of macroinvertebrates and vertebrates, of which at least 43 have an official protection status under Mexico's law [29] and/or are listed under the IUCN's Red List of threatened and endangered species and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

In the last 50 years of human use, the main users of the marine area of the LBNP have been small-scale fishers that reside within the park as well as sport fishers, mainly from the US, who

permanently reside in the community of Loreto or who visit the region primarily during winter and spring. In addition, occasional large-scale bottom shrimp and fish trawlers, sardine purse seine boats, as well as squid fishing boats and long line anglers from various and far reaching areas of the Gulf and Pacific coast of Mexico had also made use of these waters before the park was created. Historical research also shows that before persistent commercial extraction took place, the marine ecosystem might have been vastly different to what is acknowledged today. Large pearl oyster reef beds and top predators (i.e. groupers, snappers, and sharks), commonly found in the past, have been practically eliminated from today's seascape [16–18].

4.1. Creation of the park

The park was officially decreed on July 19, 1996, 4 years after the community of Loreto and its government officials began lobbying with the Executive Branch of the Federal Government for the creation of a protected area in its surrounding waters. This initiative came primarily as a result of the community of Loreto's interest to close the entry of shrimp and fish trawlers and sardine purse seine boats operating in the waters adjacent to Loreto [30].

More than 6 years after it was officially decreed, the park's management plan was established [30]. The park includes three general management zones: Zones of Restricted Use (*Zonas de Uso Restringido*), Zones for the Sustainable Use of Resources (*Zonas de Aprovechamiento Sustentable de los Recursos*), and Protection Zones

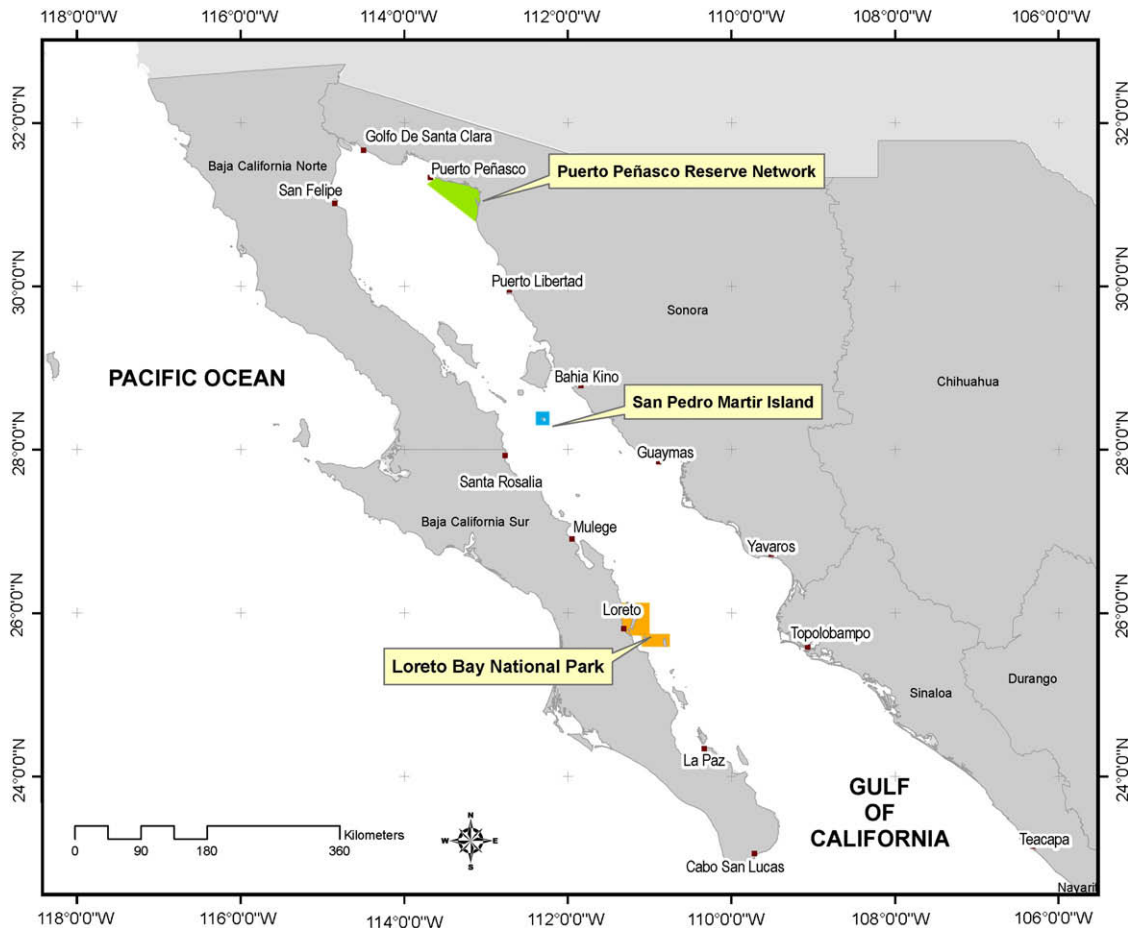


Fig. 1. Location of the Puerto Peñasco, San Pedro Mártir Island, and Loreto Bay marine reserves.

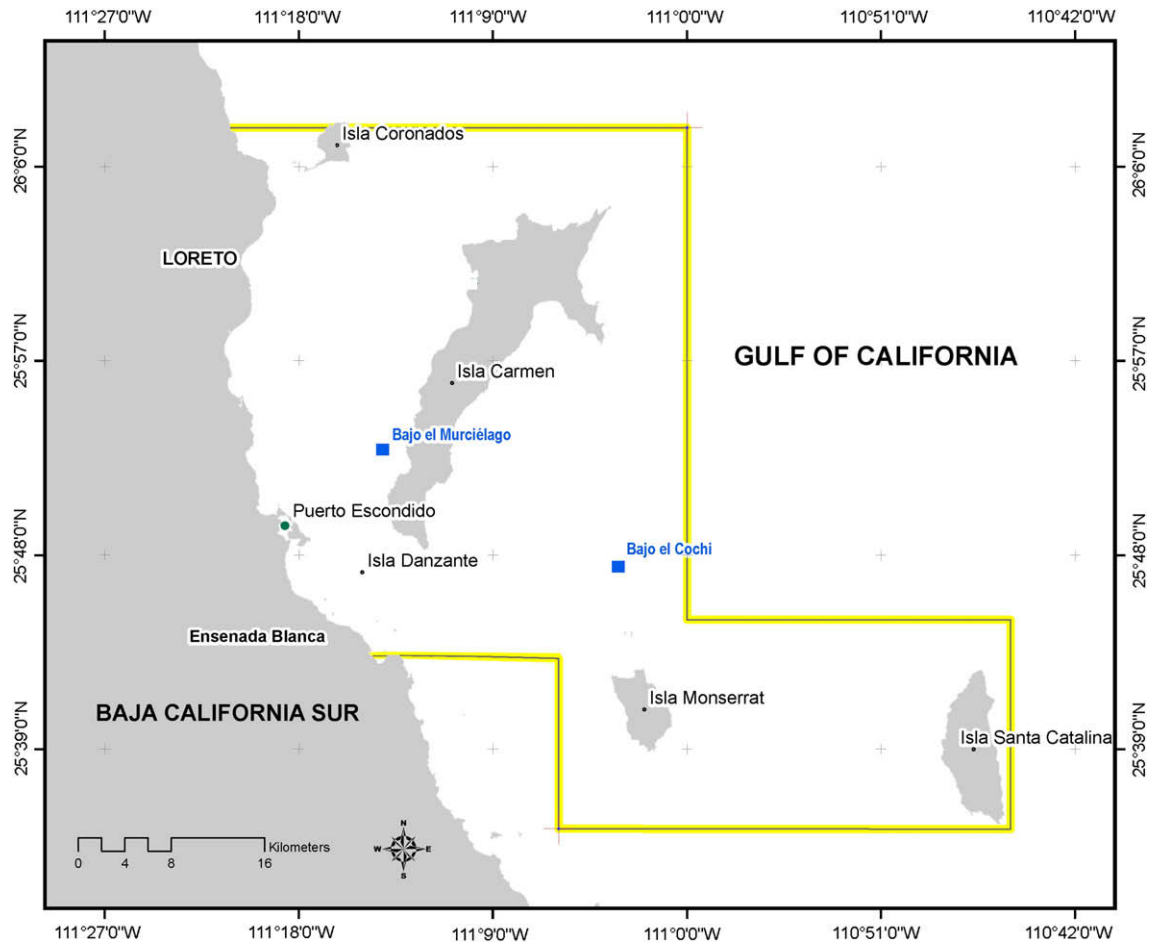


Fig. 2. Loreto Bay National Park and location of el Bajo del Murciélago and Bajo el Cochi no-take zones.

(*Zonas de Protección*). In all of these areas, large-scale fishing activities (shrimp and fish trawling, sardine purse seining) have been prohibited.

Each management zone has other specific restrictions, such as spatial-temporal control of sport fishing, commercial diving, and of the use of gillnets and longlines. As part of the Protection Zones' specific restrictions, in 2002 the park added to its management structure two no-take marine reserves: the *Bajo del Murciélago* and *Bajo del Cochi* sea mounts.

4.2. *Bajo del Murciélago* and *Bajo del Cochi* reserves

In July 2001 the park directorship, based on the petition of local fishers, set out a notice to revise the park's existent management program, a program that had been operating informally as it had yet to be recognized and published by the Federal Government. This notice was in part a response to concerns of small-scale fishers over some of the restrictions on the use of gillnets in the park.

Parallel to this process, *Comunidad y Biodiversidad* (COBI), a marine conservation and community development NGO operating in northwestern Mexico, had been working for a year in the park, locating large predators (groupers, snappers, sharks), critical habitats and obtaining baseline biological data on some of these sites. Also, COBI had conducted semi-structured interviews with fishers to assess their attitudes and perceptions towards the establishment of no-take marine reserves as tools for fishery management. In a meeting shortly after the call for a revision of the Program had been presented, representatives of local fishing

cooperatives and the tourism sector re-negotiated the zoning of the park as well as other management guidelines. By the time the meeting took place, fishers came with a proposal to establish the *Bajo del Murciélago* and *Bajo del Cochi* as no-take zones (Fig. 2). These seamounts are important aggregation sites for large groupers and sharks and, according to fishers, had provided some of the best catches in the past. However, they only comprise less than 1% of the park's marine area (1.4 km²). Because of their small size, they cannot be considered effective management or conservation measures beyond a localized scale. This is clearly understood both by fishers as well as by the parks' personnel. Rather, they are being treated as management and conservation experiments.

Interviews with Loreto fishers and the park's management team indicate that the interest to propose the establishment of no-take marine reserves had two primary purposes: (a) provide a baseline for comparison and to test the use of no-take marine reserves as a means to restore declining fish stocks in these sites and, (b) use this initiative as a leverage tool to negotiate the softening of gillnet restrictions and obtain new fishing permits.

4.3. *The current status of the LBNP and its marine reserves*

Undoubtedly, the initial conception of the LBNP had strong support from the tourism and small-scale fishing sector, particularly because it granted some form of "exclusive" access rights to fishers from the municipality of Loreto and managed to keep large-scale boats away from the areas used by small-scale fishers. However, there are currently mixed attitudes towards the

restrictions the park has established on existing fisheries. This has been accentuated by an accumulated disbelief in the government's seriousness to respond to and formalize the petitions that have been crafted at a local level. As mentioned before, it took 4 years for the government to formalize the initiative for the establishment of the park. Even after this, for 6 years practically all of the park's rules and regulations lacked any legal weight, as no management plan had been formalized.

Underwater censuses indicate that since 2002 overall reef fish diversity has decreased significantly outside reserve boundaries but not within [31]. In addition, while abundance of commercial species such as leopard grouper (*Mycteroperca rosacea*) and yellow snapper (*Lutjanus argentivestris*) remained stable inside both no-take zones, their numbers decreased drastically in the fishing areas monitored. Reserves have also been shown to be more "stable" places than fishing sites; while in the no-take reserves 12 species showed significant variations in abundance within reserves, 26 species showed significant variations (decrease and/or increase) within fishing sites [31].

An important limitation of the LBNP monitoring program is that it has little power to assess the strict restrictions that have been set for trawling on the park's soft bottoms. We know little about how populations and habitat complexity of soft bottoms have responded after more than 10 years of protection from trawling. Nevertheless, preliminary interview data revealed that up to 33% of fishers consider that soft-bottom species have recovered since the park's official closure of shrimp trawling [32].

Finally, one obvious concern for the park is its current insufficient enforcement capability. Certainly, LBNP is not alone when it comes to difficulty in accessing resources for enforcement, as protected areas in Mexico are largely under-budgeted and enforcement capabilities are still in their infancy [6]. The existent enforcement structure of the park is clearly insufficient to monitor an area of such magnitude. Furthermore, there are inconsistencies as to the designation and overseeing of enforcement responsibilities. The park does not have the political authority for enforcement, needing to orchestrate enforcement operations with other governmental agencies such as CONAPESCA, Mexico's Federal Environmental Protection Agency (*Procuraduría Federal de Protección del Medio Ambiente*, PROFEPA), and the Navy. Although increasingly effective, the need for this constant coordination comes at the expense of significant transaction costs to the park. Recent experiences involving the municipal government show promising results for increasing the presence of authorities and simplifying enforcement arrangements.

5. Community-based reserve network in Puerto Peñasco

The community of Puerto Peñasco (PP) is located in the state of Sonora, bordering the Upper Gulf of California and Colorado River Delta Biosphere Reserve. It is the largest community in the northern Gulf (~40,000 people) and one of the most important commercial ports in the Gulf, with an active fleet of 120 shrimp trawler boats capable of working throughout the Gulf [15] and 230 small-scale fishing boats.

In the northern Gulf, possibly no other fishing sector better exemplifies the rapid evolution of community-based management practices as the small-scale hookah (air compressor) diving sector of PP. Using a modified paint-spraying machine as an air compressor and long (50–100 m) hoses, divers have been harvesting benthic shellfish (snails, pen shells, scallops, clams, octopus) and reef fish (large groupers and snappers) in the rocky reefs and adjacent sand flats of this region for the past 30 years. Today, these habitats are partly within the boundaries of the Biosphere Reserve and extend eastwards to San Jorge Island, one of the northernmost rocky islands of the Gulf of California located ~ 30 km southwest of PP.

5.1. Dependence, scarcity, and the emergence of collective action

Through the fishery's brief existence, the region saw an evident decline in the availability of these resources, primarily black murex snail (*Hexaplex nigritus*) and rock scallop (*Spondylus calcifer*). Concerns about this decrease led these divers collectively to adopt more precautionary behavior [23]. In 1998, they approached the Intercultural Center for the Study of Deserts and Oceans, CEDO (*Centro Intercultural de Estudios de Desiertos y Océanos*), a community-based conservation and research NGO based out of Puerto Peñasco, to help conduct an ecological assessment of their benthic resources.

After the first 2 years of work, in 2000 the divers convened to discuss future management guidelines. From this meeting, they petitioned the federal government to establish a season closure for black murex snail, a petition that was granted in the summer of 2001 by the National Institute of Fisheries. In addition, without waiting for government recognition, in October of 2000 the divers defined and established a temporary harvest refugia MPA surrounding San Jorge Island (3 km coastline) to provide a refuge and a site for larval recruitment and dispersal of commercial benthic organisms, primarily black murex and rock scallop.

In October 2001, the divers participated in an extensive survey of the density and age class distribution of various commercial species. The outcomes of this participatory monitoring process were two-fold: not only were the results encouraging (i.e. larger sizes of individuals, increased density), but also the diving sector perceived first-hand positive products of their efforts and were collectively empowered to continue with similar initiatives [23].

5.2. Poaching and the reinforcement of cooperative institutions

Information about PP reserves traveled fast among small-scale fishers. Divers from the community of Bahía de Kino, located by road approximately 600 km south of PP and 8 h away by boat, harvested rock scallops on San Jorge Island soon after PP divers had conducted their monitoring efforts. Given the lack of any formal governmental recognition of the island as an MPA, local fishers could not count on the government for enforcement support. After several attempts to deter interloping, what followed was a textbook "tragedy of the commons" pulse of events. As soon as the first neap tides arrived, PP divers headed to the island in frenzy and joined the Bahía Kino divers to harvest as many rock scallops as possible, enough to saturate the local market.

Another incident of snail poaching also took place soon after the San Jorge events. On this occasion, however, Puerto Peñasco divers believed they had the legal means to denounce this activity and approached the then local natural resource enforcement agency (*Procuraduría Federal de Protección al Ambiente*, PROFEPA). Nevertheless PROFEPA did not provide any assistance since the season closure had not been published in the *Diario Oficial de la Federación*, Mexico's Federal Register. In essence, the agency established that it did not have any means to enforce locally-based decisions, even if backed up by the National Institute of Fisheries. The process, however, to get a law published through the *Diario Oficial de la Federación* is lengthy and highly politicized, involving time frames, resources, and efforts that can seldom be afforded by fishers and the state of their natural resources.

Interestingly, events that seemed to have undermined any future management efforts appear to have reinforced the evolution of cooperative institutions. In spite of the lack of government support, in early 2002 the PP divers convened to discuss the past set of events and define future management guidelines, the main ones being the use of marine reserves as a management and conservation tool parallel with the establishment of exclusive fishing access rights.

5.3. Puerto Peñasco's network of reserves

Having seen what was perceived as a positive and rapid ecological response of the short-lived San Jorge experiment, PP divers opted to establish a network of three reserves, including San Jorge Island and two coastal areas (Fig. 3). The entire network covers 18 km of coastline and gives protection to approximately 30% of the divers' historical fishing grounds. The divers' interests behind the establishment of these reserves was three-fold: (a) to see if over-exploited areas could recover, (b) to increase the number and density of commercial species within all closed areas, and (c) to test if the reserves not only increase recruitment within the closed areas but in actively fished sites as well. Divers agreed to close off these areas for a period of 3 years, at the end of which they would re-assess future management efforts. In the meantime, they also lobbied to obtain legal recognition of their initiatives, including the granting of an exclusive fishing zone for the harvest of benthic mollusks.

To test the efficacy of reserves, PP divers began monitoring commercial species, measuring density and age-class distribution of benthic mollusks within reserve areas and control sites (areas open for fishing). As part of this effort, they began a cooperative fund for monitoring their fishery resources, anchoring marking buoys, and traveling to the state and federal fishery offices to lobby their petitions. CEDO, in collaboration with the University of Arizona, facilitated obtaining funds for this monitoring effort, designed with fishers the means to monitor reserves, analyzed the results, and trained divers for ecological data acquisition. Once the

decision to establish these reserves had been made, fishers convened a meeting with the Mexican Navy, the Chief of the Puerto Peñasco Fisheries Office, the Director of the Upper Gulf Biosphere Reserve, local buyers, and representatives of NGOs. Divers presented their proposals and discussed ways in which their efforts could be supported by the government at a local level.

5.4. A brief aftermath

The reserve efforts in Peñasco have provided mixed outcomes both from an ecological as well as institutional perspective. Almost 3 years after the establishment of reserves, monitoring of reserves and fished sites showed that San Jorge's rock scallop population had recovered since the last major harvest took place 3 years before, with densities six times higher than those in all the coastal areas monitored [33]. Density of juveniles of commercial mollusks in fished areas at the downstream edge of the reserve network increased three-fold since reserve establishment suggesting a direct benefit of reserves by means of larval dispersal [33]. In addition, average size of harvested snails and breeding aggregations increased significantly, and aggregations were found in shallower waters in areas previously overexploited. These results were consistent with fishers' overall opinion about the efficacy of their closures, expressed both through interviews with all cooperative members as well as during cooperative meetings [23].

The divers' example led local and federal government agencies to be more actively engaged in the support and implementation of

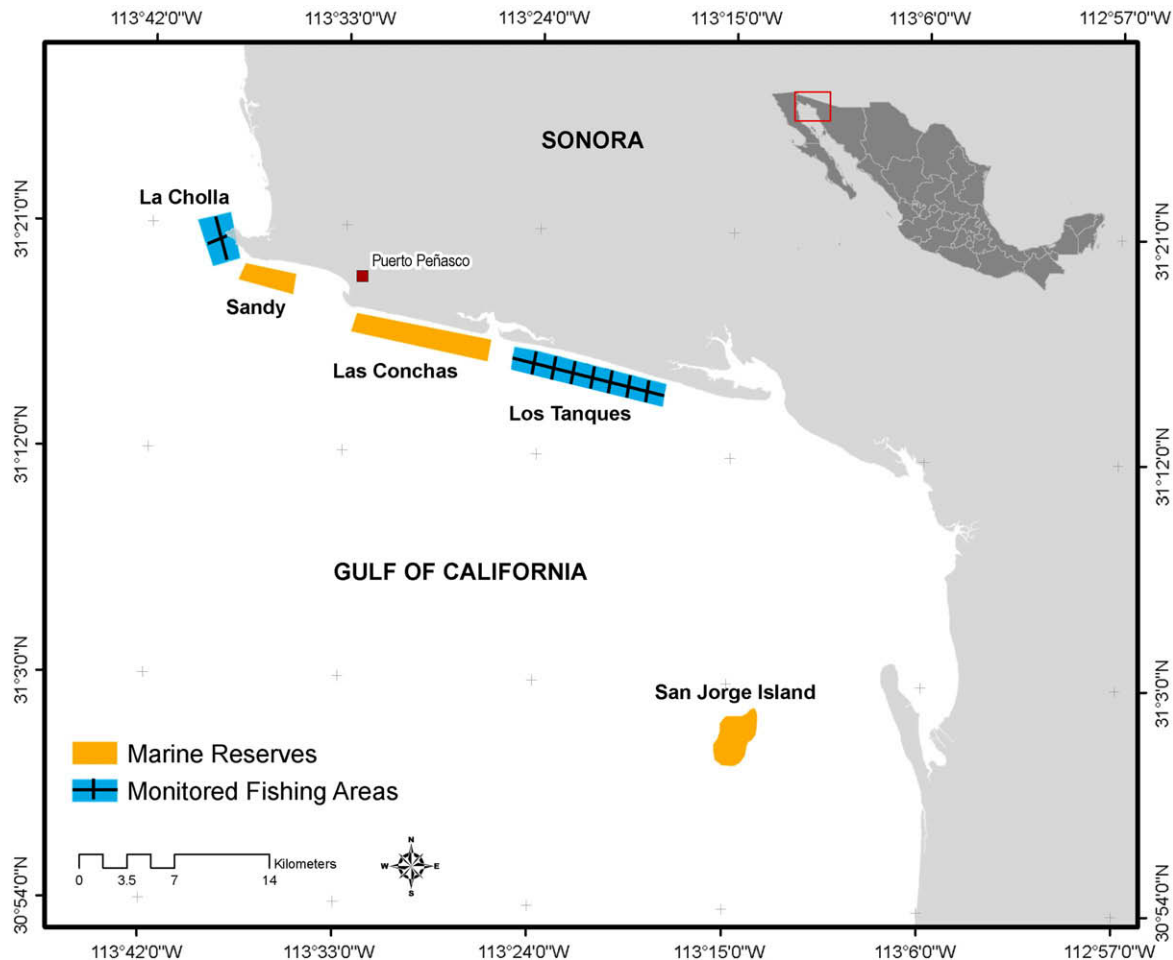


Fig. 3. Marine reserve network of Puerto Peñasco, Sonora, Mexico.

their management initiatives. The Navy and local fisheries office, for instance, initially participated in several patrolling and enforcement operations of the reserves and snail season closure. These supportive actions were based primarily on the rapport built between the divers and local government officials, as the reserves were yet to be formalized at a federal level.

In November 2003, Mexico's federal government awarded the Puerto Peñasco diving cooperative Mexico's National Conservation Recognition, one of the highest environmental distinctions bestowed annually by the Secretariat of the Environment. Soon after, CONAPESCA granted the cooperative some, albeit not all, of the fishing permits that fishers had lost during a national fisheries restructuring process that took place in 2000. Rather than acting as a positive incentive, however, the incomplete granting of permits caused strife within the cooperative and forced divers to work under other permit holders or illegally. There was a high expectation that all permits would be granted, especially given their efforts to manage their fisheries in a more sustainable manner, the recent National Recognition, and the fact that these permits had been paid for during four consecutive years with all investment lost.¹ Concurrently, the directorship of the local fisheries office changed drastically, bringing in personnel from outside the region who were unaware of existing local institutional arrangements and overall less supportive of fishers' management initiatives. This made it impossible for divers to gain local government support for enforcing San Jorge island as a reserve, which by then had become a highly productive fishing ground [33]. After various confrontations with interlopers and unable to deter fishing, the divers convened and opted to collectively fish on the island before others would continue free-riding on their efforts.

The aftermath of what occurred in PP provides a different scenario. In summer, 2006, the Mexican government granted a fishing concession to the PP Cooperative, providing exclusive access rights to rock scallop fishing grounds. Soon after, a regional management plan for harvest of rock scallop was developed,² explicitly laying out the need for a summer season closure, total allowable catches, and the establishment of harvest refugia. These measures will be re-established by 2009 after population assessments are implemented.

6. San Pedro Mártir Island: the creation of a biosphere reserve

San Pedro Mártir is the most oceanic island in the Gulf of California, located in the Midriff Island region more than 60 km away from both the states of Baja California (Baja Peninsula) and Sonora (mainland México) (Fig. 4). This small island (2.89 km²) was decreed a biosphere reserve in 2002 after 2 years of lobbying from the Sonora State Offices of the Area of Protection of Flora and Fauna (*Área de Protección de Flora y Fauna*),³ Gulf of California Islands, and two conservation organizations: *Comunidad y Biodiversidad* (COBI) and the World Wildlife Fund (WWF) Gulf of California Program. The reserve has an area of 302 km² – including 3 km² of the island and 299 km² of surrounding marine area. The marine area is divided into 9 km² of a no-take core zone and a remaining 290 km² buffer zone [34].

¹ It is not uncommon for the Mexican fisheries permitting process to be tied down in bureaucratic discrepancies, and for fishers to unsuccessfully invest time and money to obtain and/or renew their fishing permits.

² Adherence to the guidelines of the management plan is a requisite established by the Federal Government in order to keep the concession and be allowed to harvest the resource.

³ This office belongs to the National Commission of Protected Areas (CONANP), the agency of the Federal Government in charge of managing Mexico's protected areas.

The island serves as one of the world's most important breeding grounds for blue-footed boobies (*Sula nebouxii*), brown boobies (*S. leucogaster*) and for six other seabirds [35]. Its adjacent waters harbor a high diversity of fish, and act as an important feeding and reproductive ground for large commercial species (i.e. groupers and snappers), sea turtles and marine mammals. Regarding commercial fishing, the marine area of the reserve is used almost entirely by small-scale fishers from the community of Bahía de Kino [35], a small fishing community of 5000 people in the state of Sonora. Small-scale fishing from other communities in Sonora and Baja California, as well as large-scale shark fishing, shrimp and fish trawling and sardine purse seining also occasionally take place in the island's surrounding waters. In addition, sport fishers mainly from the US target the island to fish for large groupers and pelagic species such as yellowtail jack (*Seriola lalandi*) and dorado (*Coryphaena hippurus*).

6.1. Creation of the San Pedro Mártir Biosphere Reserve

The conditions under which this MPA was created were very different from the other two cases previously discussed. Here, the initiative to begin a discussion with the fishing community of Bahía de Kino to establish the biosphere reserve emerged from the Federal Government. The regional offices of the Gulf of California Islands Protected Area became interested in re-categorizing San Pedro Mártir as a biosphere reserve and adding the marine environment to the overall management and protection of the island.⁴

In 2000 *Comunidad y Biodiversidad* (COBI) was selected in an open contest and hired to conduct a feasibility study for the establishment of a new protected area by facilitating a negotiation forum between fishers and the government. As part of the assessment, a series of workshops were conducted in the community of Bahía de Kino after having obtained baseline information regarding fishers' and local government officials' perceptions towards the establishment of marine reserves and their interest in protecting the island's marine resources. The initial workshops included talks about the use of marine reserves as fishery management and conservation tools. These were followed by a negotiation workshop with stakeholders, including fishers and government officials, to design the final zoning of the new reserve.

From this negotiation, a formal proposal was presented in late 2000 to the federal government to re-categorize the island as a biosphere reserve, a proposal that took 2 years to be formalized and published in the Federal Register. The proposal included a core zone that, although only comprising approximately 3% of the marine area of the entire MPA, protected approximately 30% of the island's coastline and its adjacent fishing grounds.

There are several reasons why fishers agreed to establish a large portion of the island as a no-take area. The most important, however, was that the island has always been seen as a temporary refuge. Given its location (more than 60 km offshore from both Gulf coasts), the island is not an area that is regularly used by individual fishers. Even more so, it is only used by a select group of them. The island is a backup area where fishers can get good catches when having the time, money, and willingness to make the trip. A visit to the island can require fishers to camp three or four nights. These short trips, however, are often enough to take a heavy toll on the island's isolated populations of reef fish. Much of the fishing is

⁴ In 1978, San Pedro Mártir, like most other islands in the Gulf of California, was decreed a Zona de Reserva y Refugio de Aves Migratorias y de la Fauna Silvestre (Reserve and Refuge Zone for Migratory Birds and Wildlife). However, this protection only included the terrestrial component of islands.

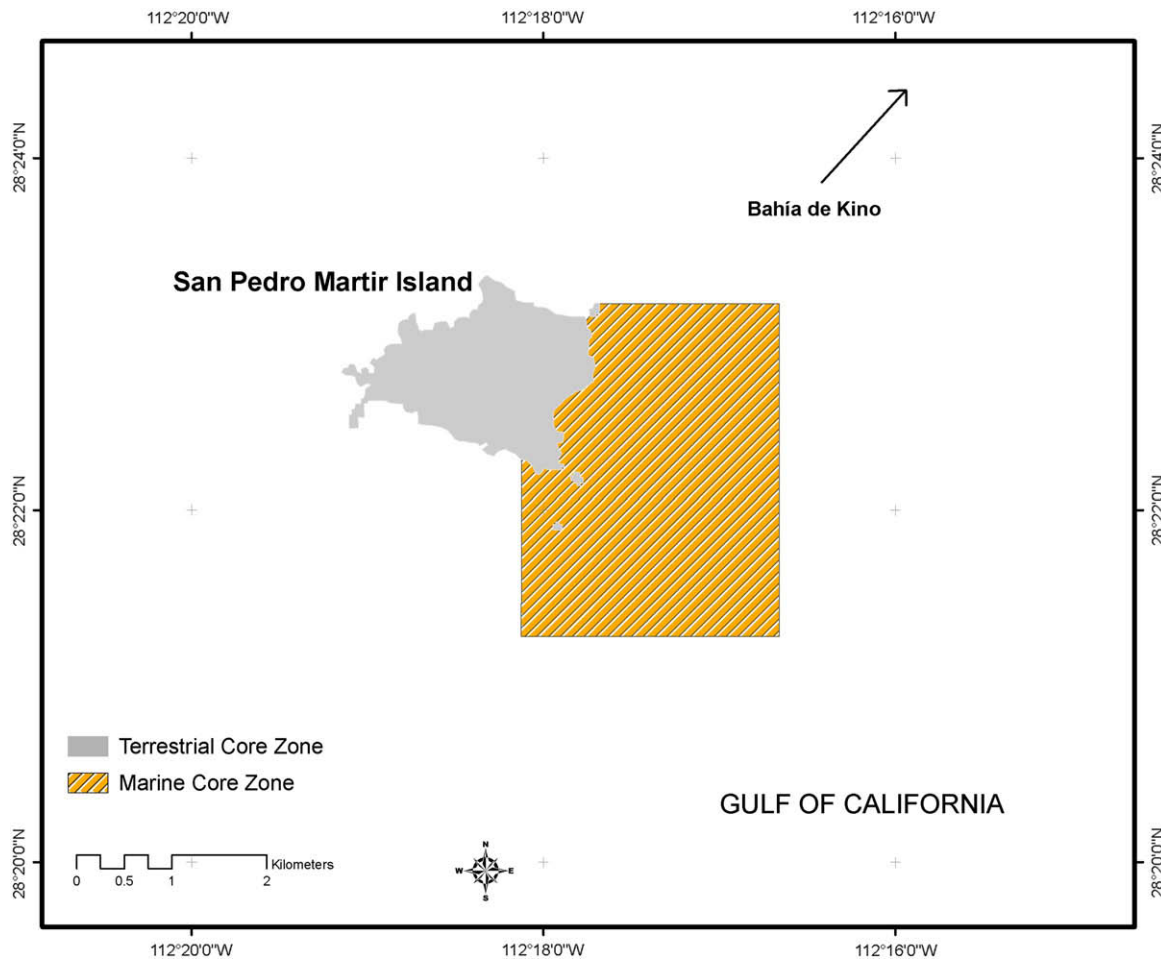


Fig. 4. San Pedro Mártir Island Biosphere Reserve. Figure frame represents the limits of the reserve's buffer zone.

carried out at night – illegally – using diving equipment, fish hooks, and spear guns when fish are most vulnerable. Yet, there is a prevalent general belief that the island's populations quickly “bounce back” if there is not much more pressure from other fishers.

Given this, when the government proposed to establish a core zone in the reserve, fishers agreed to its establishment since they did not have much to lose and conceivably had more to gain by testing it as a management tool. This came after considerable debate over the exact location of the core zone and its size. To illustrate part of this negotiation, when a fisher proposed protecting an area that was evidently a very poor one for fishery purposes, another fisher replied:

Para qué ese lugar? ... es como tener un gallinero sin gallinas/Why that place? ... it's like having a chicken farm without chickens.

In addition to the island's far reaching location, part of the attraction of establishing a biosphere reserve with a core no-take zone was that Bahía de Kino fishers would be given preferential access to the area and the reserve would give a legal means to control access of highly impacting fishing activities such as bottom fish trawling. Mexico's environmental law states that communities within and/or near reserves have special access rights to these areas [36]. However, these conditions have not been formalized and enforced, as an official management program for the SPMI Biosphere Reserve is yet to be published.

6.2. San Pedro Mártir today

Six years after the establishment of SPMI as a biosphere reserve, it is still lacking enough personnel specifically dedicated to its management, monitoring, and enforcement. To date, most of the basic operational tasks have been conducted by the Director of this MPA, who is also the Director of the regional office of the *Area de Protección de Flora y Fauna Islas del Golfo de California* of CONANP, working in collaboration with NGO's such as COBI, the *Grupo de Ecología y Conservación de Islas* (GECI), and the Prescott College Center for Cultural and Ecological Studies, a field station that has been working in education and research in the region for over 20 years. The official management program was written by these institutions, presented in public hearings, and published in December 2007.

Between January 2003 and April 2008, researchers from these institutions and staff from the MPA conducted “surprise” visits on 258 separate occasions to record human activities. On 39% of these visits both commercial and sport fishers were seen fishing within the core zone, even after an extensive public education campaign. In May 2004, a large sport fishing derby took place on the island in which indiscriminate fishing was conducted for over a week, targeting rare species such as gulf grouper (*Mycteroperca jordani*) and giant sea bass (*Stereolepis gigas*) as well as leopard groupers and jacks. Given this, more efforts are being invested in monitoring human activities and enforcement. The reserve staff and COBI are conducting 4-monthly visits to the island and have solicited formal

enforcement from PROFEPA, Mexico's Federal environmental protection agency.

COBI has been conducting underwater monitoring of commercial species and of overall diversity of fish and invertebrates. As part of this monitoring effort, this institution has engaged the participation of members of the commercial diving union of Bahía de Kino. This has largely come about as a result of the example set by the Puerto Peñasco initiative. However, because of the lack of effective enforcement, these data are only being treated as baseline for future comparisons of fishing and no-take areas.

Finally, in 2006 the reserve staff, COBI, Prescott College and WWF developed a strategic plan that ultimately aims at making SPMI a marine reserve model. This includes working with local stakeholders and international partners to design the most suitable option for managing resources outside the reserve and implementing a plan for the long-term financial sustainability of the reserve.

7. Discussion and conclusions

As evidenced throughout this paper, the Gulf of California is experiencing a rapid evolution of institutional arrangements and the emergence of challenging management actions aimed at conserving biodiversity while also maintaining fishing life-styles and economies and a high productivity of fishery resources [5]. This evolution has been fueled largely by steady downward trends in production per capita, an increase of people making use of the Gulf's marine resources, and by the direct and indirect influence of NGOs. One manifestation of these changes is the interest in the establishment of different forms of MPAs [6].

Here we have presented a general overview of some of the first efforts to establish no-take marine reserves for management and enhancement of small-scale fisheries and conservation of marine ecosystems in northwestern Mexico. Although it is certainly too early to give any conclusive remarks as to the long term efficacy of these reserves, we can shed some light on the main conditions that have led to the emergence of these efforts and the key processes that are governing their performance.

7.1. Dependence, scarcity, and resilience

Dependence on and scarcity of natural resources have been identified by various scholars in common pool resource (CPR) theory as two of the main factors leading to the emergence of cooperation and self-governing institutions [37,38]. In this particular case, these factors have been key conditions leading to the interests of fishers, NGOs, and Mexico's National Commission of Protected Natural Areas (CONANP) in establishing marine reserves. Clearly, the state of the Gulf's fishery resources has declined when compared to what it used to be 100 or even 20 years ago [18,19]. We believe that it is precisely this decrease in fishery resources combined with belief in the ecological resilience of the Gulf that has largely facilitated the emergence of conservation actions. In the three cases here described, fishers have evidently experienced a decrease in catches and depend on their fishery resources year round. However, the state of their natural resources is not at a level such that it is no longer worth the initial costs associated with the establishment of MPAs. They have also experienced, in some form or another, positive responses of the system when protected from fishing.

7.2. Local ecological knowledge, stakeholder monitoring, and return rates of social-ecological feedbacks

Fishers are unlikely to engage in any conscious management effort if they do not believe it will bring some benefit in the future. This requires, at the very least, some knowledge of the resilience of

their system and clear proof of the positive outcome of their management actions. Some marine systems, however, may take many years to show any sign of recovery. In areas of the world where commercial fishing has been the *modus operandi* for centuries, sufficient empirical knowledge regarding response rates of the marine environment may have been gained and passed on through generations, making long-term sacrifices more justifiable. However, in many areas of the world where commercial fishing has been a relatively recent endeavor, insufficient knowledge of the system's response time frames makes sacrifices seldom affordable to fishers. Here we have provided evidence of a blend of local ecological knowledge, stakeholder participation in monitoring, and relatively rapid response of the fisheries on which fishers depend bringing about a reinforcement of their institutions. This is particularly true in the PP case. We hypothesize that the growth rate of resources harvested, coupled with the divers' direct underwater observations of their natural system, has accelerated the accumulation of ecological knowledge and facilitated informal trial and error processes. The ultimate reinforcement and collective social-ecological feedback, however, has come with fishers' participation in monitoring programs.

7.3. MPAs as negotiation opportunities for access rights

The establishment of MPAs can be seen as negotiation opportunities for stakeholders to acquire access rights to fishery resources and preferential use of fishing grounds. Faced with the government's proposal to establish MPAs, fishers and communities have a better means to demand some form of exclusivity to the fishing areas and resources they have historically depended on. This is regardless of whether they are "buying in" to an outside entity's proposal to establish MPAs, or if the proposal emerged from within the fishing sector. The question then arises as to which communities or sectors should be granted these rights and who decides how these rights are granted.

Granting access rights will probably be the single most conflicting issue for the future establishment of MPAs in the Gulf. An example of this conflict of interest can be seen by recent events taking place in the Upper Gulf of California Biosphere Reserve. After a series of protests following the government's decision to enforce zoning rules that ban trawling within the biosphere reserve's buffer area, the government stepped back from its initial decision and gave exclusive access rights to trawlers from the communities of Puerto Peñasco and San Felipe, the two communities found on the edge of the biosphere reserve, to fish within the buffer zone with some seasonal and gear restrictions. This decision automatically excluded trawlers from the rest of Mexico's Pacific fleet. What followed was a heated response from other members of the industrial fishing sector, a series of lawsuits, removal of federal fishery employees, and state and federal politicians' adoption of the conflict for their personal election agendas.

In the three cases we have presented, fishers' adoption of MPAs has been used as a means to help petition exclusivity of fishing and territorial access rights, or to negotiate management restrictions to fishing. Currently, the government has granted access rights to the communities that lie within the LBNP, has established a territorial fishing concession for PP commercial divers and, in the case of SPMI, is in the process of evaluating the granting of territorial access rights to the community of Bahía de Kino, which has historically been the primary user of the island.

7.4. Distance of reserves

How far away a fishing area is found from shore will largely determine how often it is used. Although SPMI – in the case of Bahía

de Kino – and San Jorge Island – in the case of Puerto Peñasco – are some of the richest fishing grounds for fishers of these communities, their distance from shore makes fishers target other areas that are closer on a more regular basis. Part of the reason why fishers from these communities have opted to establish these islands as reserves is that historically they have already been treated as forms of temporary refugia. Nevertheless, there is evidently a tradeoff as well. Enforcement costs and effectiveness will likely increase with the distance at which MPAs are found. Areas found closer to shore can be more easily monitored by local fishers during their regular fishing activities or even when on shore. Incidentally, the belief that other fishers within and outside the community will respect near-shore reserves may increase. For areas that are farther away and out of fishers' immediate control, on the other hand, there can always be mistrust whether they are being poached in or not. In this regard, transaction costs associated with enforcement will likely be the most important challenge for management of both San Jorge and San Pedro Mártir islands.

7.5. *The government's role*

Our three case studies show different levels and types of involvement of the Mexican government in the design, establishment, and management of reserves. This involvement has been crucial in various ways. Most importantly, the federal government has acted as a means to both legitimize as well as destabilize some community efforts.

Currently, there are four means to operationalize a no-take reserve in Mexico: (1) if it forms part of an existent MPA (i.e. LBNP), (2) if a new MPA is created in which no-take zones can be included as part of its management scheme (SPMI), (3) if an indigenous community is granted territorial use rights and opts to establish a no-take zone within this territory [39], and (4) if an organized group (e.g. a fishing cooperative) is able to amass various species-specific fishing concessions that grant exclusive fishing rights over those resources within a specified area and the group decides to close a portion of this area to all fishing of the resources over which it holds exclusive fishing rights.⁵ In essence, then, in order to have any legally recognized no-take marine reserve, it will likely fall within one of the management categories of Mexico's national park system (i.e. National Park, Biosphere Reserve), currently overseen by the National Commission of Natural Protected Areas, or via grassroots decisions operating within government-granted forms of exclusive fishing access rights (i.e. marine territories of indigenous communities or species-specific fishing concessions).⁶ The government's formalization of an MPA, however, represents the only legal means to grant exclusive fishing rights to fishing communities while at the same time aim at conserving the marine environment through a comprehensive ecosystem approach. This can also support the justification for reinforcing official enforcement of other fishery management guidelines such as season closures and gear restrictions.

Nevertheless, the government's involvement and/or lack thereof can also destabilize community initiatives and undermine future grassroots efforts. In the three cases presented, community

initiatives have operated on very different time frames than those of the government. In addition, the constant restructuring of fishery administration in Mexico – from a Federal Secretariat to a Commission – has led to important consequences in terms of budget reductions, confusion as to which agencies are held accountable for what, and inefficiencies in bureaucratic processes. To exemplify this, with the changes in the Presidential Administration that came about in 2000, bureaucratic problems caused many small-scale fishers to lose their fishing permits during their renovation process. Many of these permits were never renewed, forcing fishers to work illegally or under the auspices of other permit holders.

7.6. *Role of NGOs and academia*

In the three cases presented, NGOs and academia have played an important role in empowering stakeholders, producing data and proposals with scientific backup, facilitating the communication of fishers with local and federal government entities, and working with the government and fishing sectors to establish reserves as management and conservation tools. They have also provided a more neutral forum for discussion of the issues at play and, consequently, some of the scenarios necessary for the evolution of institutions for co-management. At the same time, they have taken some of the financial, logistic, and technical burden off essential monitoring processes and have helped bridge local ecological knowledge with experimental design, offering a powerful means to validate fishermen's knowledge and actions within higher local, state, and federal entities.

However, NGOs and academic institutions must work in close coordination and communication with environmental and fisheries management government agencies, at times battling to be perceived as allies in the fulfilling of their institutional mission. Further studies should address the effects of these institutions on the social dynamics of the region and study the perception of both local stakeholders and government alike on the role and effectiveness of these institutions.

8. Recommendations

The Gulf of California is an appealing place to establish and test the use of marine reserve networks as management and conservation tools for various reasons. Its productivity could facilitate measuring tangible outcomes for some species in short and affordable time frames. In addition, the current deteriorating condition of the Gulf's fishery resources and the existing drive to establish forms of territorial use rights, particularly in the case of benthic resources, could facilitate the establishment of marine reserves. However, blindly considering reserves as the optimal fisheries management and conservation tool could lead to more problems than solutions. Given the interest of NGOs and government officials in establishing reserve networks in the Gulf [10,27] and the fact that reserves could increase in number in the years to come, we provide the following viewpoints and recommendations.

Part of the difficulty with the establishment of marine reserves worldwide is that, often, fishers do not believe they are established in their best interest and there is seldom tangible proof to show if they are, indeed, effective. Therefore, we must pay particular attention to communities or fishing sectors that are already showing signs of interest in their establishment, and to systems in which we can measure results in relatively short (i.e. 2–5 years) time frames. One good point of departure may be the establishment of refugia for benthic sessile or semi-sessile fishery resources. The fact that these resources are more generally constrained within a geographical area than other resources (i.e. most fin fish) may

⁵ CONAPESCA, Mexico's Fishery Commission, grants fishing concessions as a form of exclusive fishing access right within specific areas. However, these concessions are species-specific, and a group will need to have several concession titles to have control over the most important resources in order to have meaningful exclusivity rights.

⁶ Under the Mexican Fisheries Law, *Refugios Pesqueros* (Fishery Refugia) can also be established. However, although a useful management tool that has been under utilized, these refugia, as with fishing concessions, are currently operational at a species-specific (not ecosystem-based) level.

facilitate monitoring and assessment of basic population parameters and of the spatial distribution of fishing activities. This characteristic can also lead to well-defined management zones of reserves and facilitate access control to exploitable stocks. These systems also lend themselves to facilitate the involvement of stakeholders in the ecological monitoring process. Although it may represent a logistical challenge, stakeholder involvement in research can be a critical component for the success of any future or existing marine reserve, as the burden of proof on their efficacy falls primarily on stakeholders themselves and not necessarily on an external entity.

Nevertheless, even if the majority of fishers believe in the purpose and benefits of reserves, problems with poaching will likely arise when legal fishing and territorial access rights to communities investing in reserves are lacking. As stocks within a reserve become richer, they can act as magnets to outside fishermen. This may eventually result in not only more damage to the harvestable stocks than if a reserve had not been established, but it may also give way to territorial and social conflicts between users. Given this imminent threat, the Mexican Government will need to designate more resources for enforcement and, where appropriate, ease a legal structure in which fishers can control access to fishing grounds. It is also evident that there is a substantial lag between the government's actions and the petitions of fishing communities. Community management petitions that the government is interested in supporting will require a more efficient formalization. Slow responses cause stakeholders to stop believing in the seriousness of their government and undermine their efforts to continue establishing encouraging management and conservation schemes.

In addition, because no legal harvesting occurs in reserves, establishing a reserve – at least temporarily – will reduce the size of the harvestable stock. Increasing harvests of unprotected stocks often compensates for this reduction. It is important, therefore, to assess the spatial–temporal changes in fishing effort and species targeted after the establishment of reserves. Furthermore, simply prohibiting harvest in a reserve does not ensure that populations of all target species will recover to pre-harvest conditions within the reserve and begin to replenish adjacent populations [4]. Responses will likely be species-specific and expressed at differing spatial and temporal scales.

Finally, the ecological and social–political processes operating in the Gulf of California must not be treated as separate entities, but rather as a unit with two components giving feedback to and influencing each other. When established, we must rigorously address the effects of reserves not only on the ecological resilience of the marine system and the economic well-being of fishing communities, but also on the existing social institutions, networks, stocks of social trust, and norms that shape these communities. In a region where enforcement capabilities are insufficient and will likely never be enough, this social capital could ultimately act as a pillar for long-term sustainability if backed up by a more robust legal framework that gives appropriate recognition of *ad hoc* local and regional management initiatives.

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