A community-based marine reserve network in Northwestern Mexico*

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Introduction

There is an increasingly broad recognition that fully-protected marine reserves are some of the most powerful tools to overcome globally spread overfishing problems [1-3]. Scholars all over the world have made a clear call to implement networks of fully protected marine reserves that could represent world bio-geographic regions and help recovering vulnerable and depleted species [3, 4]. Although this is a clear policy statement with little controversy among scientists, the practical design of these networks has sometimes been misunderstood, encouraging academics to propose large reserves with little consideration of socio-economic constrains [5]. A good example is the model developed for the Gulf of California and published in 2002 in the journal Science [6]. Although this model brings a novel mathematical approach to incorporate ecological, social and economic concerns in the design of fully protected reserves networks, it was tested on the wrong scale. As a result, the model ends up proposing large areas as no-take zones, where complete fishing villages are proposed to be excluded from their fishing rights (i.e. Seri Indian marine territory) [6].

Despite the fact that creating such large areas could appear extremely promising to conservationists, we might better remember the lesson provided by Icarus, the Greek son from Architect Daedalus. According to the Greek mythology, Daedalus built with feathers and wax wings to allow them to escape from Crete [7].Despite his father caveats on flying close to the sun, Icarus approaches the aster, his wings melted and he felt into the sea without accomplishing his venture. Proposing such large fully protected reserves, ignoring the dependence of coastal economies on marine species, is just as dangerous as Icarus' approach to the sun. They risk loosing the fisher's support, probably the best potential allies for reserves stewardship. In this paper we propose an alternative approach to establishing large marine reserves networks, one step at a time, in partnership with fishing communities who are genuinely worried about the marine species depletion that their sustenance depends on. The approach includes direct capacity building of local fishing communities and NGOs in the design, establishment and monitoring of marine reserves, funding for the initiatives, and the design of a multi-criteria decision-making tool.

The starting seed

In 2000, Comunidad y Biodiversidad A.C.(COBI), a Mexican conservation organization, started a pilot project to develop a community-based methodology to implement networks of fully-protected marine reserves[‡]. The first networks were planned within the boundaries of two natural protected areas in the Gulf of California (San Pedro Mártir Island Biosphere Reserve and Loreto Bay National Park) (Figure 1), and to be in fully agreement with local communities. The idea was to encourage setting these reserves as community experiments to recover (or at least to see how they recuperate) depleted species. Interestingly, fisher's concerns on depleted species matched the ones identified by the literature as very vulnerable to fishing, such as large predatory fish, mollusks or sea turtles that are easy to catch [8, 9].

In San Pedro Mártir Island, almost one third of the coastal ecosystem was declared as no-take zones in 2002 as a result of the official decree of protection. The main objective of the reserve was to recover some depleted species identified by fishers such as turtles, groupers and mollusks. In Loreto Bay, two small seamounts were established in 2003 as no-take zones, mostly as scientific experiments

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[‡] The term marine reserve is ongoing used as fully protected. For official decrees of protection, we will use the term "natural protected area". In this areas, normally a zoning program that includes fully protected marine reserves is established.

to elucidate the effects of artisanal fisheries in reef ecosystems. The experiment in San Pedro Mártir , however, has not yet started, mainly due to the lack of financial and human resource to implement a monitoring program. In contrast, governmental allocation of financial resources and Park staff in Loreto Bay, have make this experiment successful and three years after the establishment of Loreto's no-take reserves, we have gathered interesting results of a broad regional relevance. For example, to evaluate the success of our communication program directed to the stakeholders of the park, we applied a survey to assess how the management rules were understood by users before our program take place and how understanding changed rules compliance after our program was applied. In 2002, we applied the first series of surveys to elucidate awareness of users on the management rules. In 2003 we started a communication program that consisted of producing and distributing widely pamphlets, posters, installing signs in public places, and giving talks to the community disseminating precise information of Loreto park boundaries and rules. The percentage of users that localized correctly the park boundaries, increased from 13%to 73%, and the percentage that knew correctly were the no-fishing zones are located increased from 13% to 50% after our program was applied. This, in turn, had a positive effect on the rules compliance; while in 2002-2003 we did not find fishers within the no-take zones boundaries during 67% of our monitoring visits by 2003-2004 this percentage had increased to 88%. While it is commonly believed that policing is the only mean to ensure protection compliance, our results show that communication is also key to improve better compliance of rules, at least in the beginning.

Another important result of these no-take reserves was new insight on the impact of artisanal fisheries in reef ecosystems. The results of four years of monitoring by underwater censuses show that populations of some of the most vulnerable reef fishes (groupers, snappers and parrotfishes) have significantly decreased outside the reserves boundaries in the last three years, but remained stable within the boundaries of the no-take zones (Figure 2). Parallel to these species depletions, reef fish diversity has decreased significantly outside the reserve boundaries but not inside the reserves (Figure 3). Before this data was available, there was no hard data to support that even small scale fisheries have deep effects of the community structure of the Gulf of California reef ecosystems.

Multi-criteria decision supporting tools: from simple to sophisticated reserve designs

The creation of networks of marine reserves is one of the greatest examples to illustrate the complexity of an environmental decision: it assessment requires information from multiple points of view, demands compromises with particular objectives, calls for relatively rapid solutions, and might involve wide groups of stakeholders. As in any other decision making process dealing with the environment, multi-criteria evaluation techniques are some of the most suitable tools to deal with these problems [10, 11]. As implied on its name, multi-criteria evaluation is a method that allows decision-makers to incorporate different points of views when evaluating a set of possible decisions. It most important robustness is that some of the algorithms allow mixing criteria assessed with quantitative information, along with those criteria for which only qualitative or descriptive information is available or possible. In addition, it also lets decision-makers to give importance to criteria that is more relevant in their decision-making process, compromising their final choice with specific objectives. Applying this technique also offers an opportunity to incorporate traditional knowledge and local stakeholders' insight in describing the ecological features and sites of particular importance, such as breeding aggregations or nursery areas. To deal with the problem of how different marine protected area's networks could be more suitable to different localities, we used a technique called EVAMIX [12] and programmed the algorithms in visual basic to make it user-friendly.

To illustrate the versatility of this tool, we show two examples from the Mexican Northwest Region with sets of criteria used to evaluate possible alternatives of networks of marine reserves, San Pedro Mártir Island Biosphere Reserve and Natividad Island (Table 1). All the more than 900 islands and islets found in the Gulf of California are protected by a presidential decree from 1978. This decree covers the terrestrial areas, but not the surrounding waters. In 2000, COBI was appointed by the Federal Government to develop a technical proposal that would include San Pedro Martir's surrounding waters as marine protected area. We decided to take a participatory approach to develop this proposal. Being some of the smallest (2.9 km^2) and most isolated islands of the gulf (41 nautical miles from the coast), San Pedro Mártir lacked on that time data on fisheries or an assessment of its biologically important marine sites. However, full protection of some of its surrounding waters provided an excellent opportunity for conservation; populations of marine species occur in some of the most isolated places of this enclosed sea, making them extremely fragile, and fishing pressure is relatively low compared with the rest of the area. Additionally, for political timing, we were asked to finish the study in three months. To do a rapid assessment of a series of alternatives, namely to select the best choice of zoning for no-take zones, we selected a panel of experts, including fishers, scientists and government authorities. The different alternatives, the criteria and the assessment of the alternatives were done in full collaboration with the panel during two workshops. All the criteria (except the area that was calculated using Geographic Positioning System) were assessed in an ordinal scale, one being the best choice and five the worst (since the panel proposed five alternatives). Criteria can be read in Table I.

The second example of the use of multi-criteria to design marine reserves comes from a fishing cooperative that has exclusive fishing rights for almost all benthic species (except the kelp *Macrosystis* spp) in the waters adjacent to Natividad Island (See figure 1). This small populated island (less than

10 km^2 and 500 inhabitants) is located right off the central west coast of the Baja California Peninsula (see map). Concerned with the historical depletion of abalone species (*Haliotis* spp) and its fragility to environmental fluctuation, fishing cooperative members acceded to evaluate the possibility of establishing a small network of reserves, mainly to recover abalone species, as a scientific experiment. In order to present to the cooperative assembly (made of all 85 members) the cost and possible benefits of a network of reserves, the assembly approved to conform a team to evaluate different possibilities of networking the reserves. This team of experts was made of fisheries technicians from the cooperative, expert fishers who are locally recognized by their fishing and diving experience, and staff from COBI, as the conservation and scientific counterpart. Criteria and alternatives were designed by the team; nevertheless in this case the process was very different from San Pedro Martír, due to the large databases of information available on resource distribution, abundance, fishing statistics, characterization of habitats, etc. Criteria and ways to assess them can also be seen in Table I.

Fisher Fund

After two years of implementing the pilot project in San Pedro Mártir Island Biosphere Reserve and Loreto Bay National Park, grass-root conservation groups and local fisher's organizations from several fishing communities in the Mexican Northwest region, called for our support to plan and implement parallel projects in their own communities. Recognizing our inability to attend many projects in several communities simultaneously, COBI, with the support of The Nature Conservancy, decided to organize a one-week hands-on workshop entitled "Design, establishment and evaluation of no take fishing zones as a tool for conservation and management of marine ecosystems in North-western México". The objectives of the workshop were to build the capacity building of seven fishing communities, located along the coast of the Gulf and the Baja California peninsula, in the design and implementation of marine reserves, and to develop a network of organizations interested in this conservation and management tool with strong local community involvement. In the workshop, we trained eight fishers and eleven biologists from six fishing cooperatives, two governmental agencies and five non-governmental organizations. The workshop program was divided in five essential topics for establishing a community-based reserve network; first we presented a series of worldwide documented examples of impacts produced by fishing activities on targeted species and the consequences on the species natural histories and well documented cascade effects on ecosystems [13]. In the course we also described the benefits of marine reserves identified by the literature, illustrating this with the best documented case studies [14, 15]. We also presented the participants with monitoring methodologies and management effectiveness indicators [16] and finally, we presented a review of the legal framework that can be used to formally declare marine protected areas in Mexico. The theory sessions were complemented with five case studies presented by fishers from Mexico, Belize and United States (Channel Islands and Florida Keys) which emphasized the fishers' involvement in all the steps to create reserves. In teams formed by a fisher and a biologist, the participants had the opportunity to apply some of the learned concepts by designing several hypothetical reserves network, and assessing them using a simple multi-criteria tool and by carrying out underwater monitoring exercises.

The participant's willingness to promote marine reserves in their localities by far exceeded our expectative. Besides, they recommended bringing more information to their communities related to the benefits of marine reserves, creating local capacities, promoting community leaders to increase awareness of this management tool and encouraging fisher's exchanges to learn directly from the fisher's themselves about the benefits and difficulties of establishing marine reserves. The extensive fishers' ecological knowledge of their fishing zones, combined with the biologist technical experience, worked effectively as a team to design a realistic set of possible networks that would accomplish conservation of marine resources and maintenance of sustainable fisheries in the long-term.

The main result of the workshop was the establishment by COBI and The Nature Conservancy of an initiative named "Fondo Pescador" or the *Fishers Fund*. The main objective of the fund is to provide technical and financial support to fishing communities interested in promoting and establishing no-take zones in their communities. The fund works with the fishing communities and associated NGOs to prepare and review proposals and, it provide close follow-up to the seven community projects developed during the workshop. It also provides capacity building of fishers through fishers' participation in national and international meetings and field visits, and it encourages the use of complementary conservation tools such as fisheries certification and strengthening of local property rights. During 2004 and 2005 we searched for funding and developed detailed work plans for each community, following each community's distinct local processes. The projects that are supported by the fund are : 1) a recovery program for highly valuable and endangered abalone species in full collaboration with the Natividad Island fishing cooperative, who has the exclusive fishing rights over these species in their fishing territories; and the potential lease of a kelp forest concession for the purpose of conservation, 2) the creation of a refuge for the endangered Pacific green turtle (*Chelonia mydas*) inside Magdalena Bay; 3) the development of an underwater monitoring program in Cabo Pulmo National Park, refuge of the northern limit of hermatypic corals in the Pacific Ocean; 4) holding stakeholders workshops to define the most suitable marine reserve network for Espíritu Santo Island (87 km^2), the most intensively used island by tourism in southern Baja California; 5) the development of a management plan for aquarium fish harvest in Loreto Bay

National Park, following the standards of the Marine Aquarium Council; 6) a series of community workshops to expand the already established no-take zones and increase their numbers inside Loreto Bay National Park; 7) a plan to manage the fishery of pen shell (*Pinna rugosa* and *Atrina* spp.) through an exclusive fishing rights system by a recently formed organization of commercial divers in Bahia de Kino; and 8) the promotion of exclusive fishing rights for an organization of commercial divers in Puerto Peñasco, with the objective of implementing reproductive reserves for the Gulf of California endemic black murex snail (*Hexaplex nigritus*) that is threatened due to poaching activities (Figure 1). All these projects are designed in close partnership with local partner organizations, including fishing cooperatives and NGOs, and they all propose networks of reserves designed trough the multicriteria tool described in the section presented above.

Conclusions

From endangered sea turtles to severally depleted abalone species, as scientific experiments, or to monitor some of the northern limits of global important coral reefs, the community-based reserves we are promoting through the Fondo Pescador will represent a robust network of marine reserves, mainly because they are supported by local fishers. From the year 2000 to today, little by little, almost 10 Km^2 of fully protected reserves have been created (Figure 4).Although this area remains far from the goal needed to protect species at a regional scale, it offers a step by step process in the creation of agreed refugees for endangered species. In the short time that Fondo Pescador has operated, we have learned that fishers are completely aware that totally protected marine reserves benefits as a management tool. However, the lack of technical, financial and legal support for these community efforts are diluted in the daily fishers activities. The role of conservationist then is to encourage local willingness to implement and support this strategy by enforcing tenure over marine resources and fishing areas as exclusive fishing rights, by financially supporting initiatives to create marine reserves, and by giving technical advice during all steps of the process, most importantly in collaborative research that can show if the reserves are working or not.

Currently, no fisheries in North America are managed through marine reserves; in contrast, popular management tools like quotas, seasonal closures and size limits, among others, have failed to ensure long term sustainable catches and to deal with environmental uncertainty [17]. Examples all over the world are demonstrating that marine reserves, although not a panacea, are one of the most suitable tools used to cope with the environmental degradation problems related to overfishing [1, 2, 18].

We often think in the term "community", as a society that belongs to an isolated, rural and poor village. However this concept could be applied at different scales to different fisheries. To coastal fisheries, communities that might be involved in the decision on how to protect certain parts of the fishing grounds are mainly the costal villagers and they are indeed small and isolated. However, for migratory species, like sharks or tunas, "the community" might be represented by fishers of several villages, along large territories, some of them involving many countries. The methodology we applied and the software we will produce could be applied for any of these cases, whenever someone is willing to create a community-based network of marine reserves. The community-based model we presented here to create these reserves using a bottom-up approach, has the potential to be implemented in other places of the world, and is a strong instrument to eventually develop large scale networks of marine reserves with local participation of stakeholders.

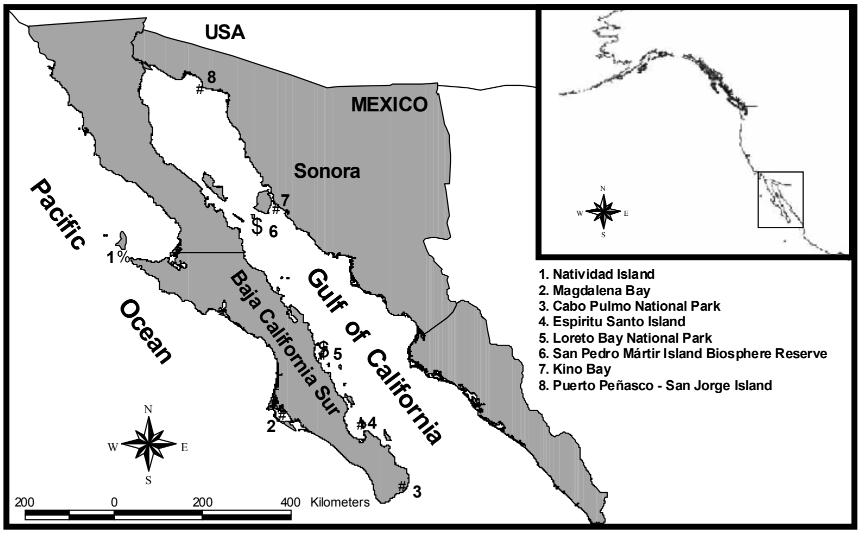
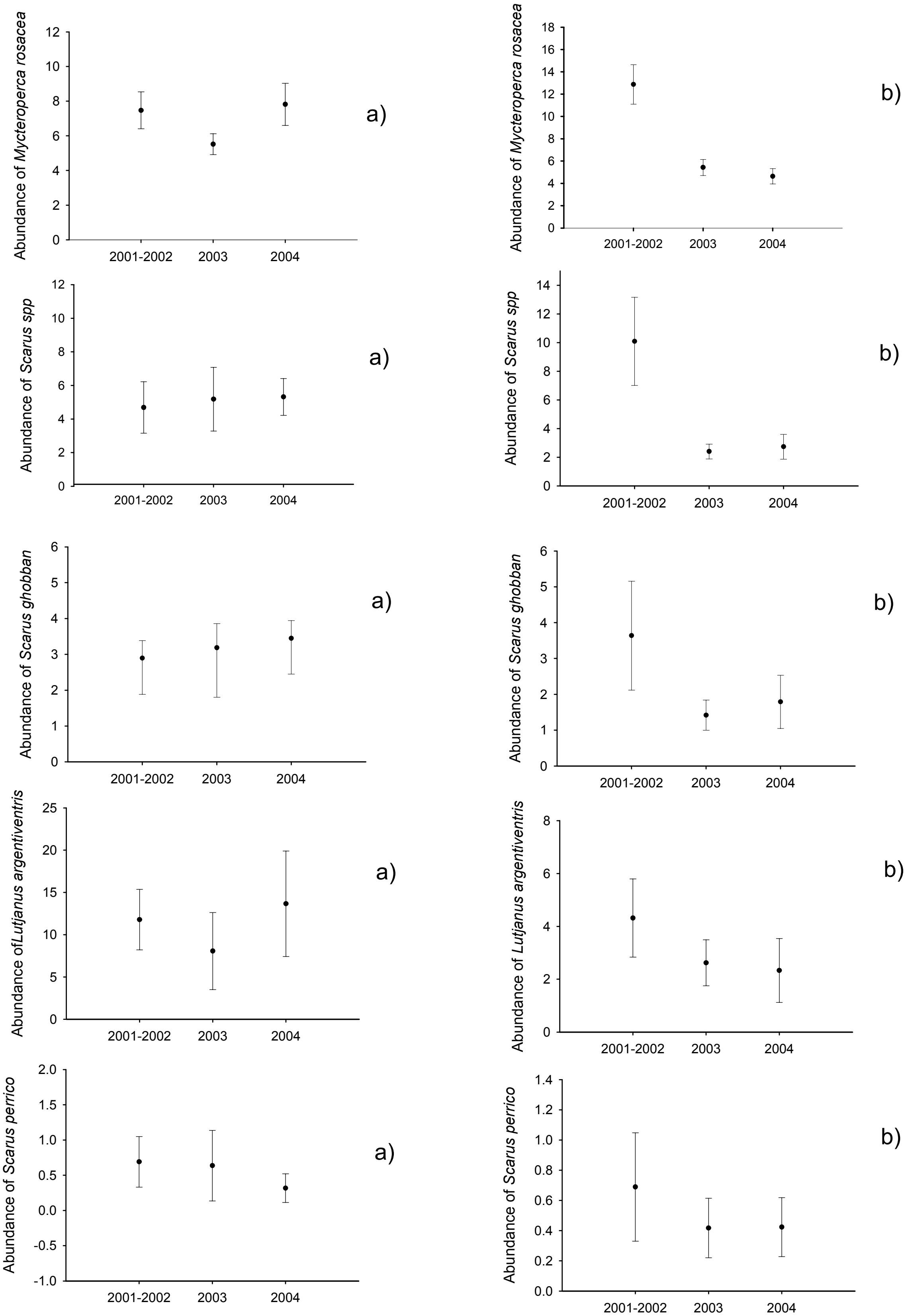


Figure 1. Sites of our projects. Pilot projects (San Pedro Mártir Biosphere Reserve and the Loreto Bay National Park) that have established no-take reserves (in triangles). Natividad Island, to illustrate the criteria used in a complex multi-criteria design (in square); here reserve creation was recently accepted by the cooperative in April 2005. In circles all the ongoing projects.



Abundance of Mycteroperca rosacea
a)
b)
Abundance of Scarus spp
a)
b)
Abundance of Scarus ghobban
a)
b)
Abundance ofLutjanus argentiventris
a)
Abundance of Lutjanus argentiventris
b)
Abundance of Scarus perrico
a)
b)
2001-2002
2003
2004

Figure 2. Data on the impact of fishing inside and outside marine reserves in Loreto Bay Marine Park. Abundances of vulnerable commercially important species (leopard grouper *Mycteroperca rosacea*, parrotfishes *Scarus* spp, bluechin parrotfish *Scarus ghobban*, blumphead parrotfish *Scarus perrico*, yellow snapper *Lutjanus argentiventris*) per 50 x 5 m transect. a) No significant change inside the reserves, b) Outside the reserves significant changes in all years (one-way ANOVA, $p < 0.05$; LSD test, all year significantly different at $p < 0.05$ b). The baseline years are 2001 and 2002.

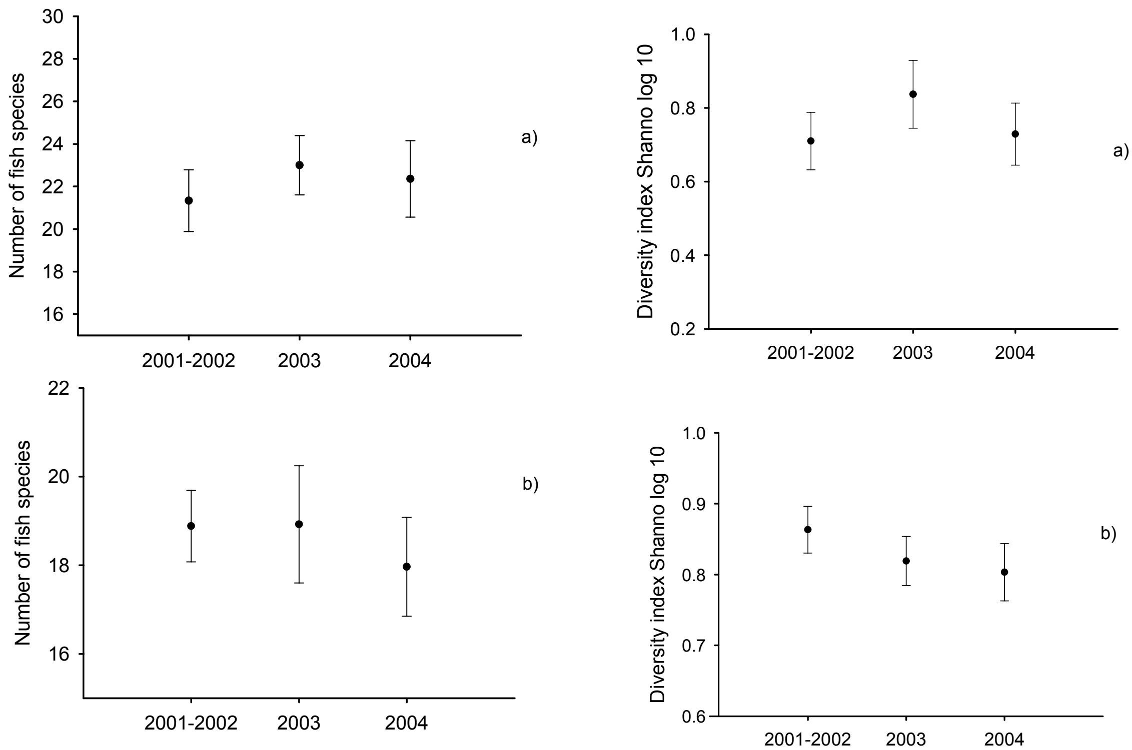


Figure 3. Data on the impact of fishing inside and outside marine reserves in Loreto Bay Marine Park. Fish diversity express in number of species and Shannon Index from 2001 to 2004 a) No significant change inside the reserves; b) Outside the reserves fish diversity presented a significant decrease (one-way ANOVA, $p < 0.05$; LSD test, presented a significant difference at $p < 0.05$ between 2001-2002 and 2004).

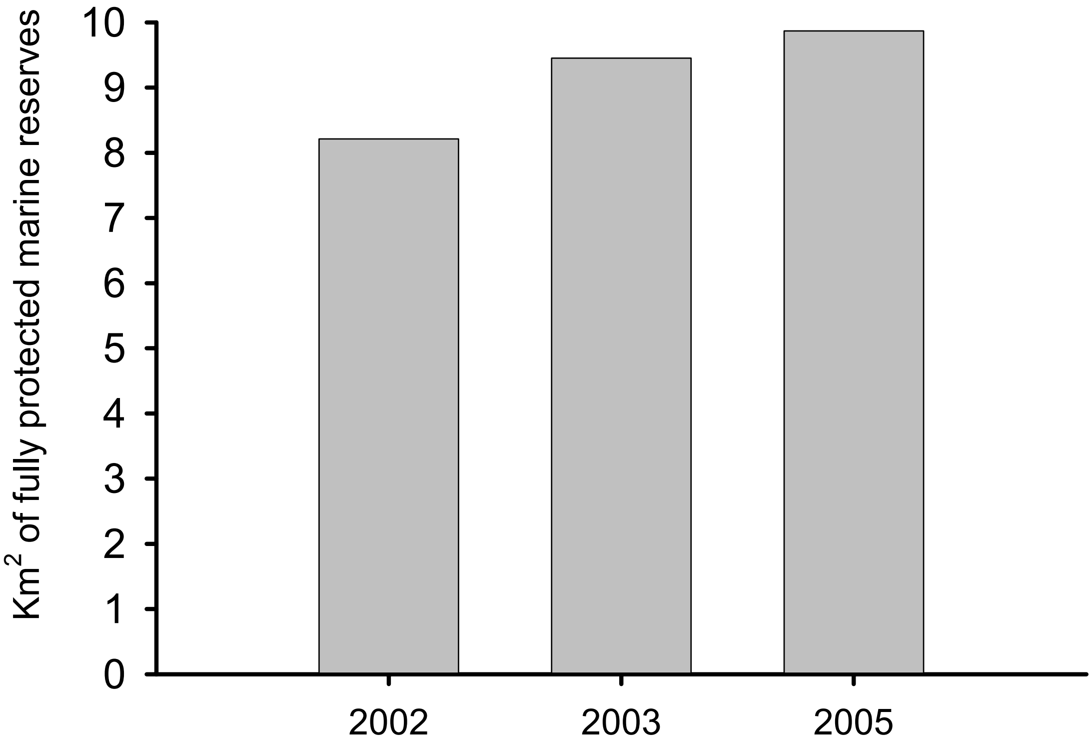


Figure 3. Square kilometers of fully protected marine reserves encouraged by our project in the Mexican northwest. Data from a) Presidential decree of San Pedro Mártir as biosphere reserve, b) publication of the Loreto Marine park management plan and c) Isla Natividad fishing cooperative "Buzos y Pescadores" approval of pilot project to recover abalone species.

Table 1. Examples of criteria than were included in the multi-criteria evaluation process. Some of the ecological criteria based on Roberts *et.al.* 2004 [19]

Criteria used in San Pedro Mártir island Biosphere Reserve (All assessed in an ordinal scale)	**Criteria used in Natividad Island**
1. Protection of important habitat and species	1. Pink abalone *Haliotis corrugata* density (organism/m^2)
2. Acceptance by local fishing communities	2. Green abalone *Haliotis fulgens* density (organism/m^2)
3. Acceptance by outsider fishers	3. White abalone *Haliotis sorenseni* density (organism/m^2)
4. Facility to apply a monitoring program to evaluate the effect of the reserves	4. Sea urchin *Strongylocentrus fransciscanus y S. purpuratus* density (organism/m^2)
5. Suitability for managing	5. Turban snail *Astrea undosa* density (organism/m^2)
6. Stakeholders conflicts decrease	6. Sea cucumber (*Parastichopus parvimensis*) density (organism/m^2)
7. Size of the reserve	7. Total value of benthonic resources found within the reserves boundaries (in US dollars)
	8. Percentage of cooperative fisheries produced within reserves area (percentage)
	9. Importance for islanders recreational use (no important, medium important, very important)
	10. Reserve area
	11. Kelp forest beds (Macrocystis spp)density (highly dense, medium dense, low dense and limited)
	12. Currents suitability for larval dispersion (optimal, medium optimal, limited)
	13. Importance as breeding site for other species (very important, medium importance, low importance, no important)
	14. Presence of seamounts (presence, absence)
	15. Presence of Depth ranges with rocky substrata (0-5, 6-12 and 13 -16 fathoms) (all of them, two, one)
	16. Presence of big boulders (presence, absence)
	17. Habitat diversity (sand, small sautéed boulders, big boulders and rocky shelf) (all of them, three, two, one)
	18. Resilience to climate change observed by fishers (very resilient, medium resilient, vulnerable)
	19. Poaching vulnerability (not vulnerable, medium vulnerable, very vulnerable)
	20. Robustness as scientific experiment (good, mediocre, bad)

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