

## Article

# Large-Scale Marine Protected Areas by Decree: Lessons Learned from the Creation of the Revillagigedo Marine Park

Andrea Saenz-Arroyo <sup>1,\*</sup>  and Vera Camacho-Valdez <sup>2</sup>

<sup>1</sup> Departamento de Conservación de la Biodiversidad, El Colegio de la Frontera Sur, Periférico Sur s/n, Barrio de María Auxiliadora, San Cristóbal de las Casas 29290, Mexico

<sup>2</sup> Departamento de Conservación de la Biodiversidad, CONACYT-El Colegio de la Frontera Sur, Periférico Sur s/n, Barrio de María Auxiliadora, San Cristóbal de las Casas 29290, Mexico; vcamacho@ecosur.mx

\* Correspondence: msaenz@ecosur.mx

**Abstract:** The increasing speed of the establishment of large-scale marine protected areas (LSMPA) on a global scale has generated intense debate among the scientific community. In this paper, we revise the declaration of the Revillagigedo Marine Park, the largest marine reserve in North America, and propose a framework to assess the potential costs and benefits of having a competitive or a cooperative strategy between the tuna fishing industry and the conservation sector. By framing scenarios in a simple model of the prisoner dilemma and using multicriteria analysis with Delphos—an open-source multicriteria program developed by NGOs for this purpose—we show how conservationists and fishers might have a potential benefit of competing for marine spaces, but not as much as they could gain if they collaborate. Our ultimate goal with this paper is to retrieve the lessons learned in this process to propose a step-by-step process that helps to improve the creation of LSMPAs in the future, thus helping improve the outcome of marine conservation on a global scale.

**Keywords:** conservation planning for marine reserves; evolution of cooperation; multicriteria analysis; game theory



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## 1. Introduction

The creation of large-scale marine protected areas (LSMPA) worldwide has increased at an accelerating rate over the last decade [1]. The debate on the functionality of these large reserves has not generally been smooth among the scientific community. There are few conciliatory positions between scientists who push for these areas and scientists worried about how this “plague” of LSMPAs is spreading throughout the world [2] with potential “perverse” outcomes [3]. While scientists who favor the establishment of large marine reserves [4,5] defend them with little empathy for the concerns expressed by a large group of social and ecological academics [6,7], the latter have not addressed what could be behind the sudden rush to protect—no matter how—the world’s last wild places. Meanwhile, politicians are applauded loudly but briefly by the international community for protecting enormous areas of their national waters as no-take marine reserves, without committing any financial resources for their long-term protection. In addition, some of the only users and potential partners to endorse marine conservation strategies in the pelagic environment, such as tuna fishers, become significantly alienated. In this paper, we have used the declaration of the waters surrounding the Revillagigedo Archipelago in Mexico (Figure 1) as a marine park (RMP) as an example of how society is losing what could potentially be gained by creating these large reserves in full collaboration with the fishing industry. There is not a clear definition of what constitutes an LSMPA; experts diverge on the coverage size that they should include larger than 30,000 km<sup>2</sup> [8], larger than 100,000 km<sup>2</sup> [9], at least 150,000 km<sup>2</sup> [10] or even larger than 240,000 km<sup>2</sup> [11].



**Figure 1.** Revillagigedo Marine Park.

The Revillagigedo Islands are located 300 nautical miles east of the Mexican port of Manzanillo (Figure 1). This archipelago is still a good example of how coastal ecosystems and marine diversity in Mexico used to be in the recent past [12]. It is renowned for its biological richness and unique diversity of life [13]. Its remoteness has protected it from the rapid and careless development, which characterizes the Mexican coasts. Incidentally, the Revillagigedo Archipelago has become a natural refuge for the megafauna that used to be abundant in the Gulf of California, including large charismatic species such as sharks, manta rays, humpback whales [14] and turtles [15](Figure 2). In 2016, its biological and cultural importance was recognized by the global community and the islands were declared a UNESCO World Heritage Site [13].



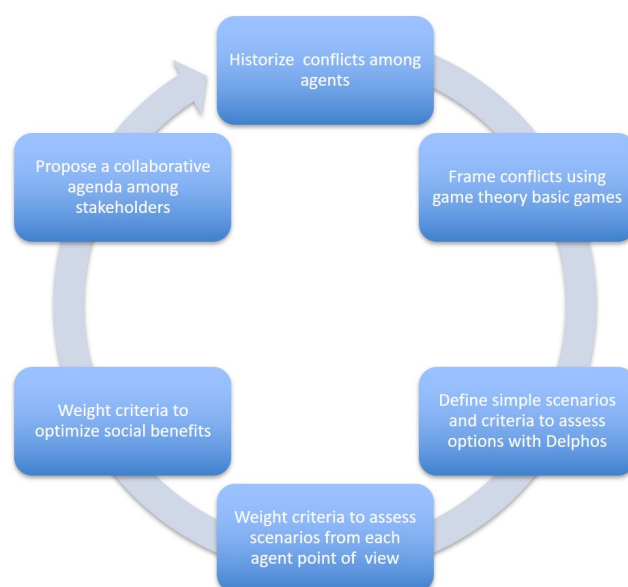
**Figure 2.** On the left: Partida Island and recreational scuba divers. On the right: scalloped hammerhead sharks (*Sphyrna lewini*), an example of the abundant megafauna that is still found in the waters surrounding the islands (Photos are courtesy of Erick Higuera).

In a fast-track declaration process, which took less than three months from the publication of the study supporting the creation of the marine park to the signing of the official decree in November 2017, the former Mexican president, Enrique Peña Nieto, declared the four islands an extensive marine zone proclaiming them a National Park [16]. The new LSMPA expanded the no-take marine reserve, which had been established since 1994 in donut-shaped polygons of 12 miles around the islands, from 4300 km<sup>2</sup> to around 148,000 [16].

Before the creation of the Revillagigedo Marine Park, the only legal users of this immense territory were scientists, scuba-diving tourists, conservation NGOs, officers from the Mexican Navy and a variety of fishers operating outside the no-take zone. Tuna fleets were using the waters surrounding the archipelago for purse seining mostly for skipjack tuna (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*), long-liners were catching several species of sharks and a sport fishing fleet from San Diego, California were mainly catching tuna and billfish. After the creation of the new LSMPA, all fishers were displaced. Despite there being areas for cooperation among all of these sectors, for the purposes of this paper we will only use the tuna purse seine fleet and the conservation sector to illustrate what is lost and gained by using a cooperative or a competitive strategy to create large marine reserves globally. The objective of this paper is to contribute to enriching the discussion with a fresh perspective on the potential effectiveness of marine conservation goals on a global scale.

## 2. Materials and Methods

From July to December 2017, the first author was involved both with the fishing industry and the conservation sector in the process to pursue a collaborative strategy for the declaration of the Revillagigedo Islands Marine Park. The collaborative strategy did not succeed but the story of the creation of this LMR in the Eastern Pacific Ocean provided important lessons to improve our strategies for marine conservation on a global level. In this paper we propose a step-by step process to understand if conservationists are trapped in a non-cooperative equilibrium in the dispute for marine territory with fishers (Figure 3), and the social costs society is affording for not encouraging a collaborative strategy.



**Figure 3.** Step-by steps process to assess non-cooperative equilibriums in the creation of large-scale marine protected areas (LSMPA).

With the information collected in this process, the news derived from the decree and the historical reconstruction of the conflicts between the conservation sector and the tuna fishing industry, we created a qualitative descriptive model of the game agents playing in

this model, using simple game theory applied for conservation conflicts [17]. Here, it is important to note, that our purpose was not to propose a quantitative economic model of the gains and losses of each stakeholder, but to illustrate the non-cooperative trap stakeholders were caught in. In order to illustrate this, we combine the qualitative description of the game theory model, with the use of Delphos, an open-source multicriteria program created to facilitate collaboration in marine conservation processes, specifically in the creation of networks of no-take marine reserves. Delphos was created by NGOs working in marine conservation (COBI, WWF and Ecostrust) to enable communities (non-trained people) to evaluate where to establish their marine reserves in order to maximize the possible ecological, economic and social benefits and at the same time minimize the opportunity cost of not fishing in the reserves. The software uses the EVAMIX method introduced by Voogd (1982) [18], which capitalizes on concordance/discordance analysis (pair-wise comparisons) and a goals achievement matrix using both quantitative and qualitative criteria, regardless of the units of measure [19]. The mathematical algorithm performs pair-wise comparisons of the alternatives resulting in appraisal scores and ranks, which basically loses the continuity of the data but orders the preferred alternative and according to the criteria choose any the weights given to these criteria (for a detail description of the method steps, see Darji and Rau 2013 [20]).

Multi-criteria decision analysis (MCDA) is an example to visualize trade-offs inherent in any decision-making process. MCDA is an effective analytical method, which supports decision-making, by exploring the pros and cons of different alternatives [21,22]. It assesses and compares alternatives based upon a set of explicitly formulated criteria, which represent the most relevant aspects in a given decision-making process [23]. In this sense, MCDA methods have been increasingly applied within the environmental field in order to support effective decision-making processes, where different preferences of stakeholders are included [24]. In this section, we present the decision dilemmas in the creation of the Revillagigedo LSMPA. The first step in a MCDA includes the identification of possible alternatives and formulation of criteria against which they will be assessed in the evaluation matrix. In this analysis, we included four scenarios of the stag hunt game described (Compete/Compete, Compete/Cooperate, Cooperate/Compete and Cooperate/Cooperate) described in the results sections. Criteria were identified based on the opinion of both sectors shared during the process to pursue a collaborative strategy for the declaration of the Revillagigedo Islands Marine Park from July to December 2017 as in the suggestion of general principles of ecological connectivity for networks of marine reserves in the region [25]. The assessment of criteria (scores) in the evaluation matrix, was constructed based on the potential costs-benefits and hypothetical compromised scenario could bring about.

### 3. Results

#### 3.1. Historical Reconstruction

##### 3.1.1. An Overview of the Mexican Tuna Industry in Relation to Marine Conservation

Over the last four decades, tuna fishing in Mexico has been an iconic maritime activity linked to the defense and use of the nation's marine territory [26]. Although fishing has been a traditional activity since pre-Hispanic times in Mexico, it was not until the end of the Mexican Revolution that President Francisco I. Madero [27] withdrew several concessions which had been granted by the government to international companies, and started to imagine a national fishing fleet. Madero's dream gained its first momentum forty years later when President Adolfo Ruiz-Cortines promoted his governmental program, "The March to the Sea" [27].

A second boost came with the international recognition of the 200-mile Exclusive Economic Zone by the third United Nations Conference on the Law of the Sea (UNCLOS III) in 1976 [28], that end with the final recognition of the EEZ until 1982 with the adoption of the United Nations Convention on the Law of the Sea (UNCLOS). Ironically, the third, and perhaps the strongest push from the Mexican Government to encourage the consolidation

of the industrial fishing fleet came about as a result of two trade embargoes in the 1980s and 1990s by the US Government on the Mexican tuna fleet [28]. The second embargo promoted the dolphin-safe labels of canned tuna, and banned not only Mexican tuna entering the US, but also embargoed commercially all countries that were buying Mexican tuna, creating a profound economic crisis in ports such as Ensenada in Baja California Mexico [25] (Figure 1). This embargo hit both Mexican and US tuna purse seine fleets. A well-documented history of the impacts the dolphin-safe labeling caused was published in the San Diego Reader, “Flipper Victorious”, and helps to illustrate the dimension of social anger against conservationists and the extent of economic ruin [29].

After the campaign promoted by the Earth Institute to not consume any tuna that was caught associated with schools of dolphins, the American purse seiner fleet ended up fishing in the Western Pacific and the Mexican tuna industry promoted a national and Central American market together with the Mexican Government, and ended up moving their factories and fleet to southern ports such as Mazatlan, Manzanillo and Puerto Madero in Chiapas (Figure 1). Mexico succeeded with their marketing strategy, significantly increasing the local consumption of tuna. While in 1982, Mexicans were consuming just 10 tons of canned tuna yearly, today the average consumption is around 91,000 tons [30,31]. However, this history also left a bitter feeling about conservationists and many doubts about what economic interests could be behind their actions, a feeling that continues to date.

The efforts promoted by the Earth Institute had a double effect for conservation purposes. On one hand, the tuna industry from the Eastern Pacific quickly and effectively reduced dolphin mortality from 133,000 caught in 1986 to just 1877 caught in 1998 [32] by applying simple fishing maneuvers, such as ‘the going backwards technique’ which forced tuna to the bottom and dolphins to the surface, and the latter were assisted by divers to jump out of the net. On the other hand, it forced the fleet to fish over floating logs (natural or man-made), associated with larger impacts on other vulnerable species [33].

A comprehensive analysis of the ecological trade-offs of having encouraged the tuna industry to stop fishing around schools of tuna associated with dolphins was carried out by Martin Hall [29] back in the 1990s. Tuna purse seiners in the Eastern Pacific Ocean have three ways of fishing: sets around schools of tuna associated with dolphins, sets around floating objects, either natural or objects deployed by the fishers, called fish-aggregating devices (FADs), and sets around free schools of tuna. Hall’s analysis shows how fishing around floating objects had 20–25% more discharges of juvenile tuna than sets around schools of dolphins and tens to hundreds more by-catch of vulnerable species, such as billfish, sharks and sea turtles [33]. This dilemma will be useful to understanding the trade-offs incurred by creating large marine reserves with a competitive strategy with the industrial tuna fleet.

### 3.1.2. An Overview of the Conservation Sector Promoting Global and Mexican Marine Protected Areas

There is still a need for a comprehensive historical review to understand the movement behind international and local NGOs, which seek to establish large marine protected areas on a global scale. However, there is no doubt that the speed of their creation has increased significantly over the last 10 years [1]. Among the scientific community, there is also consensus that the role played by large global NGOs such as the Pew Bertarelli Ocean Legacy Program and the National Geographic initiative “Pristine Seas” in advocating these LSMPAs has been crucial [2,34].

In Mexico, fully protected marine reserves have been promoted over the last 15 years by national conservation organizations, such as COBI, Niparaja and CEDO in full collaboration with local people. For the last decade, these organizations have succeeded in implementing, monitoring and maintaining 36 different coastal no-take marine reserves in the Pacific, the Gulf of California and the Caribbean. Some of them are formally recognized by the Mexican



Government and others are local agreements to evaluate how these marine reserves work to recover biodiversity and increase fisheries productivity in a collaborative way [35].

The Mexican Government's impetus to create fast-track, remote and very large marine protected areas did not exist until the second half of Enrique Peña Nieto's term in government. However, between 2016 and 2017, President Peña Nieto reversed this trend by establishing the Mexican Caribbean Biosphere Reserve, encompassing a total of 57,000 km<sup>2</sup> [36], the "Deep Pacific" with 580,000 km<sup>2</sup> [37] and in 2017, the Revillagigedo Marine Park, with 148,000 km<sup>2</sup> [16]. What was behind this rapid shift in policy?

There is no doubt that the environmental concerns about how large marine vertebrates have been systematically depleted from coastal waters [38,39] has created significant environmental awareness and social pressure for large marine reserves. For example, the environmental concern of some independent scientists working for the NGO Pelagicos Kakunjá, regarding the fate of large migratory and vulnerable species such as sharks, helped to make the case for the recognition of the Revillagigedo Islands as a UNESCO World Heritage Site [13]. Their studies were also used to justify the creation of the RMP.

Despite many attempts by some Mexican prestigious scientists and NGO officers from Mexican and global conservation organizations to increase the no-take zone around the four islands conforming the Revillagigedo Archipelago since 2015, the Mexican Government showed no sign of accepting this proposal until September 2017, when the relatively new NGO CODEMAR took the lead in the process until the declaration of the park in November that same year.

During this short period, these NGOs accompanied by some prestigious scientists promoted a TV campaign with the most important Mexican television network to discredit the tuna industry in particular in relation to illegal fishing in the waters around Revillagigedo. The images showed illegal boats operating, combined with dead sharks in fishing nets other than tuna nets, and narrated as if this were a general practice of the tuna fleet in the archipelago (See [40] as an example).

It is impossible to say how much influence this campaign might have had on the government switching from their reluctance to expanding the polygon to supporting it. However, there was an unprecedented speed from September 2017, when the back-up study was published, to the announcement of the RMP by the Minister of the Environment during the Conference "Our Oceans" held in Malta on 5 October 2017 [41]. On 27 November 2017, in a ceremony held at Los Pinos, the former Mexican president, accompanied by Sylvia Earle from National Geographic, Max Bello from Pew and José María Figueres representing Ocean Unite signed the decree to establish the largest no-take marine reserve zone in North America.

### 3.1.3. An Overview of the Consequences of the Fast-Track Declaration

In their 2003 and 2016 papers [2,42], Tundy Agardy and colleagues warned about several unintended negative consequences of implementing these large marine protected areas with a rushed strategy. Subsequently, as if a spell had been cast, many of the most important warnings pointed out by these authors became part of the narrative of the main stakeholders involved in marine conservation in Mexico. In the following section, we will describe some of the most conspicuous ones, which helped us to build the model of the stag hunt prisoner's dilemma.

#### Trading Quantity for Quality

After creating the Revillagigedo Islands Marine Park, Mexican politicians claimed that the Aichi Target 11th Biodiversity Target and Sustainable Development Goals (14.5) of having at least 10% of coastal and marine areas was not only achieved but had been exceeded [43]. Although by declaring this LSMPA, together with the ones created in the open waters of the Mexican Caribbean Sea and the Deep Pacific Ocean had certainly doubled the Aichi Target, in terms of habitat and ecosystem representativeness this was not true. Nevertheless, it was sold to the Mexican media as a conservation triumph [43].

For example, no matter how large the RMP no-take zone is, we still do not know if it can ensure the protection of a population of large, vulnerable species, such as the scalloped hammerhead (*Sphyrna lewini*). The latter is still very abundant in the archipelago but scarce everywhere else (Figure 2). To date little is known about the home range of this large migratory species, which is currently listed as endangered by IUCN. Although some interesting studies from Revillagigedo show that there might be a degree of site fidelity [40], there are still several gaps to understanding the dynamics of this species on a broader regional level. Other evidence shows that this species might use the continental coast for completing their breeding cycle. For example, many artisanal fisheries on the southern Pacific coast of Mexico and Panama record tons of juvenile and pregnant female hammerheads each year inside estuaries and close to the shore—less than 10 miles away from the coast [44,45]. Do they belong to the same populations as the hammerhead sharks found at the Revillagigedo Islands or are they separate populations? A long-term, regional study tagging hundreds of organisms both in coastal areas and around remote islands, such as Cocos, Revillagigedo and Galapagos, would need to be carried out to really understand the dynamics of this large migratory species in the Tropical Eastern Pacific Ocean for conservation purposes.

The same applies to some of the most important species of tuna found in the waters surrounding Revillagigedo. Many arguments conservationists use to promote large no-take marine reserves are related to the potential benefits these areas might have in increasing the productivity of the fishing grounds surrounding these reserves. Indeed, a recent meta-analysis shows that marine reserves effectively increase fisheries productivity helping to prevent overfishing [46]. However, to date, evidence shows that marine reserves work to a very short spatial scale—namely, hundreds of meters. The only study showing this effect in the pelagic environment is from the Galapagos Islands and demonstrates that fishing has increased in one of the boundaries of the marine reserve [47]. Could the new RMP offset the opportunity costs incurred by the Mexican tuna fleet by not fishing in these waters through the reserve's spillover effect? What are the ecological trade-offs of displacing the Mexican tuna fleet to the high seas? We still do not know the answers to these questions; however, it could be a very interesting but extremely expensive hypothesis to be tested without the support of the fishing industry.

#### **Alienation of Potential Partners for Marine Conservation**

The declaration of this large reserve affecting the fishing industry unfortunately eroded the potential to make a collaborative research program together with the fishing industry. Both research questions mentioned in the previous section are just two of multiple unsolved queries that need to be explored to really understand the complexity, which shapes the dynamics of large migratory species in the Pacific Ocean.

After the declaration of the RMP, an interesting opportunity was lost to make a partnership with the four tuna companies that together caught 50% of the Mexican tuna quota and that obtained the Marine Stewardship Council (MSC) certificate for 37 vessels (out of 69) for their skip-jack and yellowfin purse seine catch in 2017 [48]. As part of their performance improvement plan to renew the MSC certificate, these fishermen committed to reaching the goal of zero sharks as by-catch, offering a tremendous opportunity to tag hundreds of sharks in order to understand their migratory dynamics [49]. These companies together founded the Pacific Alliance for Sustainable Tuna (<https://www.pacifictunaalliance.org/> (accessed on 14 November 2018)) proposing a comprehensive plan to contribute to marine conservation.

Closing 148,000 km<sup>2</sup> surrounding the islands was indeed counter-productive to test the hypothesis of the spillover effect. If the declaration of the RMP had been the result of a participatory process, these questions might have been included as hypotheses to be tested together with the tuna fleet. However, designing the marine protected area without the fishers increased and generalized the fishers' skepticism of marine reserves as a fishing tool for large migratory species.

An example of this disbelief was the reaction to the proposal also made by CODEMAR some months after the Revillagigedo National Park decree was signed, to close 60 miles of marine waters surrounding the state of Baja California Sur to industrial fisheries. This proposal was even rejected by the artisanal fleet although it was apparently beneficial to them [50]. Immediately after that, the president elect, Andres Manuel López Obrador, made a declaration against marine reserves and assured protesters that the intention to create a new biosphere reserve was going to be stopped [51]. Accusations on the obscure interests of NGOs such as CODEMAR linked to the tourism industry were made and can still be read about in several media and social media outlets.

### Masking the Most Important Threats to the Marine Environment

The global movement to protect at least 30% of the marine environment from fishing started in the 1990s when fishing was indeed the major threat to marine biodiversity [52]. However, things have radically changed since then. Today, climate change, invasive species, pollutants, garbage and nutrient loading from land activities are seriously threatening global marine biodiversity.

Although we still need a global synthesis to understand how these drivers are currently affecting the dynamics of marine ecosystems on a global scale, taking a look at the current threats to coral reefs and the Mexican Government's attempts to protect them using no-take marine reserves [36], helps to illustrate the urgent need to move beyond the narrative of fishing as the major threat to marine diversity.

Over the last few decades, conservation strategies for coral reefs have followed the rationale that fishing for herbivorous species, mainly parrot fish, is the key driver which triggers the change from a coral-dominated reef to an algae-dominated reef [53]. The model developed by Terry Hughes to explain the degradation of coral reefs in Jamaica back in the 1990s, caused by an increasing demand of protein by human populations [53] was very useful then to understand what was triggering the collapse of coral reefs. However, in their last 2017 paper Hughes and colleagues show how things have changed since then [54]. Those local drivers jeopardizing the integrity of coral reefs back in the 1990s pale in comparison to the current global threats, mainly those derived from global environmental change [54].

The Mexican Caribbean Sea has a different trajectory of impacts to the former British colonies in the Caribbean [55], but coral reefs have unfortunately followed the same fate: from the 1980s to 2012 the most important reef builder, *Acropora palmata*, had a decline of 80% in its coral cover [56]. In the Mexican Caribbean's coral reefs, parrot fish were never caught commercially, nor are they remembered by old fishermen as a species that were once abundant [55], and they are not even registered in the zooarchaeological record [57]. Recent studies show that the decline in the reef builders species occurred when fish biomass changed very little indeed [58]. However, conclusive evidence shows that unregulated, rapid coastal development causes drainage to be filtered from the coast to the ocean with dire consequences for the resilience of coral reefs [58,59].


Although what is threatening the resilience of coral reefs in this region is different, the policy prescription was the same: a marine reserve of 57,250 km<sup>2</sup> LSMPA with a 100 km<sup>2</sup> of coastal no-take zones and almost 2 million Ha. of no-take deep sea habitat ( $\geq 100$  m) [36]. Despite pressure from many citizens' organizations, which have denounced that unregulated coastal development is destroying coral reefs, Enrique Peña Nieto took no action. Paradoxically, he left his office as a conservation hero for creating three very large, but very ineffective marine reserves.

### 3.2. A Prisoner's Dilemma Model for the Revillagigedo Marine Park

With the narrative presented in the above section we built a simple prisoner's dilemma model that could describe the non-cooperative equilibrium reached in the interaction of the conservation sector and the tuna fishing industry trapped in the creation of the Revillagigedo Marine Park (Figure 4). The game that better fits the interaction between these



two agents is the stag hunt [17], whereby the two agents have some gains by presenting a competitive behavior, but not as much as they could if they would have cooperated (Figure 4).



Tuna Fishers

		Tuna Fishers	
		Compete	Cooperate
Marine Conservationists	Compete	<div style="color: green; font-size: small;">A no-take marine reserve of 14.8 million hectares with poor ecological connectivity, a lack of funding, an increase in fishing over floating objects. Alienation of potential partners for marine conservation./Displacement from 20-30% of their traditional fishing grounds, social support and support from the new government and artisanal fishers “against conservationists”.</div> <div style="color: blue; font-weight: bold;">(1,1)</div>	<div style="color: green; font-size: small;">A no-take marine reserve of 14.8 million hectares with poor ecological connectivity, a lack of funding, an increase in fishing over floating objects, but with social support and support from the new government for having achieved a good conservation goal./ Displacement from 20-30% of their traditional fishing grounds, social and governmental discredit because of the belief that unsustainable practices and poaching is the rule rather than the exception.</div> <div style="color: blue; font-weight: bold;">(1,0)</div>
	Cooperate	<div style="color: green; font-size: small;">No new marine reserve. Social and governmental discredit because of their “obscure” sources of funding./ No displacement from their traditional fishing grounds, social and governmental recognition for their conservation achievements and economic importance. No social pressure to improve fishing practices.</div> <div style="color: blue; font-weight: bold;">(0,1)</div>	<div style="color: green; font-size: small;">A network of no-take marine reserves smaller than 14.8 million hectares. A politically and economically supported new, multi-use marine protected area with several hypotheses to be tested in a collaborative way over the next decade. Investment from the fishing industry for participatory science, and the opportunity to test how no-take marine reserves work for pelagic species./Backing from conservationists and politicians for their efforts towards sustainability. Some of their most productive areas are still open to fishing.</div> <div style="color: blue; font-weight: bold;">(2,2)</div>

**Figure 4.** A simple stag hunt prisoner’s dilemma model for the interaction between the conservationists and the tuna fishing industry in the creation of the Revillagigedo Marine Park. What the conservation groups would obtain from the interaction is in green, and what the fishing sector would obtain is in blue. The gray background represents the interaction that actually took place. The numbers represent an ordinal scale of gains obtained by each sector in the four different scenarios (Prisoners’ cartoon by Linda Lonnqvist).

In the first scenario, which is the one that actually happened, the conservationists actually obtained a truly large MPA, but they did not secure the funds for its operation, they alienated potential partners and gave politicians the excuse to affirm that marine conservation goals had been exceeded. The tuna purse seiners were displaced from what they perceived represented 20 to 30% of their fishing grounds and were pushed outside the Mexican Exclusive Economic Zone, where sets over floating objects is much more common than over schools of dolphins [60]. This fact could increase the by-catch of other vulnerable species as some reviews have found [33]. The tuna fishermen, on the other hand, have now obtained the immediate support from the new Mexican president and the support from artisanal fishermen to defend themselves from the “obscure interests” of conservationists.

In the second scenario, the fishermen would not have reacted to the imposition of the marine protected area in the media, and although the conservationists would have obtained the same sized, poorly designed MPA, with its potential ecological trade-offs of displacing the tuna fleet to international waters, they would not have confronted the negative impacts in the media for their unknown sources of funding.

The third scenario would have occurred if the fishermen had made an effective communication campaign about the socio-economic impacts of the US embargoes imposed on the Mexican tuna fleet and the role international NGOs had in promoting them. An empowered and socially supported tuna industry would have successfully promoted its conservation achievements regarding dolphin mortality and fisheries management practices, such as

their MSC certification for sustainable practices. This would have put the tuna industry in a completely different position, one in which the government would not have contemplated confronting them by establishing a no-take marine reserve without their consent. In this situation, it would not have been possible to establish the largest North American marine reserve in Mexican waters.

In the fourth scenario, the cooperative one, the NGOs would have been open to compromise their goal of the 148,000 km<sup>2</sup> no-take polygon, but negotiate for a better connectivity in coastal areas (We arbitrarily put half of the conservation sector goal). The tuna fishers were even open to making a polygon that encompassed the three islands closest to mainland Mexico (San Benedicto, Socorro and Roca Partida) (Figure 1) and a no-take zone bigger than the previously established 12-mile polygon surrounding Clarion Island. Besides this, tuna fishers did commit USD10 million dollars for the improving plan they presented to continue with the MSC certification, which could have contributed to test some of the hypothesis on the potential spillover effect the no-take marine reserves might have had. In a negotiation process guided by professionals specialized in conflict resolution, the different parties could have created the hypotheses to be tested with the proposed no-take zones and created a joint conservation fund to test these hypotheses. The different potential allies for marine conservation would not have been alienated. The fishermen would have had some of their most productive fishing areas still open to fishing, with less incentive to go fishing in the high seas. A multi-stakeholder group would have explicitly stated that this reserve was a positive step, but far from being sufficient to protect marine biodiversity in the Eastern Pacific Ocean.

### 3.3. Multicriteria Decision Analysis

With the above information, we built a simple multicriteria table that helped us to feed the Delphos program (Table 1).

**Table 1.** Qualitative and quantitative criteria used to exemplify how multicriteria decision analysis works to assess cost and benefits of collaborative or competitive scenarios to create the Revillagigedo LSMPA.

Criteria	Attributes	Description
Size of the LSMPA	Quantitative: Measure in km <sup>2</sup> Analyzed as a benefit	Both in the scenario where conservationists compete and found cooperation or competition from fishers, conservationists managed to pass the 148,000 km <sup>2</sup> as LSMPA. In the scenario where conservationists do not compete for territory the value for this criterion is zero and in a theoretical compromised scenario we place half of the size of the reserve desired by the conservationists.
Fishing ground lost	Quantitative: measure in what the percentage of the area the industry expressed they might lose Analyze as a cost	The industry expressed that the polygon proposed by the conservation sector, which was finally approved, constitutes around 25% of the fishing area where they catch tuna. In the theoretical compromised scenario, we reduce this to half as in the size of the LSMPA protected areas proposed by conservationists.
Connectivity	Qualitative: Assessed in an ordinal scale Analyzed as a benefit	(1) None = Score used if no LSMPA would have been approved. (2) Mediocre = Score used for the rectangle polygon proposed by the conservation sector and approved in the decree that does not use any data on life cycle and connectivity of endangered marine species. (3) With potential: Score for a potential compromise scenario where at least some empirical knowledge of breeding areas for large migratory species would have been used [45].

Table 1. Cont.

Criteria	Attributes	Description
Funds for conserving vulnerable species	Quantitative: Measure in USD (Millions of dollars); Funds committed for the conservation of endangered species in the region Analyzed as a benefit	With the declaration of the Revillagigedo LSMPA neither the Mexican Government nor the NGOs promoting the decree, committed funds to make sure the polygon was going to revert some threats over vulnerable species such as sharks. For the MSC certification the tuna industry committed 10 million dollars to improve their conservation performance in particular with sharks by-catch, committing to have zero mortality for the recertification [49]. In a theoretical compromised scenario, the industry was open to create a collaborative strategy to better understand shark species life history (E.G marking sharks that are released alive).
Fishing over floating objects	Qualitative: Assessed by the literature to score regional importance for this type of fishing strategy Analyzed as a cost	IATTC reports indicate that the strategy of placing floating objects is more frequent in the high seas than in other sites where islands and seamounts are found [60]. Displacing the Mexican tuna industry from where they catch 25% of the harvest implies they should expand their operations to the high seas to preserve their productivity. Thus, in this case, the actual LSMPA would have promoted: (1) Strong fishing over floating objects In case of a compromised reserve or not having a reserve; (2) Moderate fishing over floating object.
International political support	Qualitative: Assessed by the extent of the time inverted in the creation and operation of the LSMPA Analyzed as a benefit	(1) None. (2) Fast and brief. International NGOs were committed just for the promotion of the decree. (3) With potential. In a collaborative strategy for a theoretical compromised LSMPA, local stakeholders would negotiate a long-term support from international NGOs, in exchange for the creation of the reserve.
National political support	Qualitative: Assessed by the extend of the government support to the LSMPA regardless the political party in the administration Analyzed as a benefit	(1) None. Current administration did not inherit the legacy of protecting the ocean with LSMPA. (2) Fast and brief. Current administration uses their speech to protect fishers from the “obscure” interests of conservationists, but do not establish a long-term program for marine conservation. (3) With potential to create allies. After a collaborative strategy, protection of the marine environment with LSMPA becomes a national policy that resists administration changes.
Alienation of potential partners	Qualitative: Assessed in a binary scale Assessed as a benefit	(1) Alienated. In the three scenarios of competition, potential partners became alienated. (2) Not alienated. Main outcome of a collaborative strategy.

Multicriteria analysis allows users to weight criterion (prioritization) reflecting their interest, which helps illustrate the prisoner dilemma whereby agents take decisions without talking with each other. Weighting accounts for the different degree of importance of the criteria to the decision made by each stakeholder. In this example, we run the three scenarios with weights considered to simulate the presence of different perspectives during the decision-making phase:

- Scenario 1 (conservationists-oriented perspective): decision is taken based exclusively on the importance of creating a large marine reserve (Size of the reserve). We per-

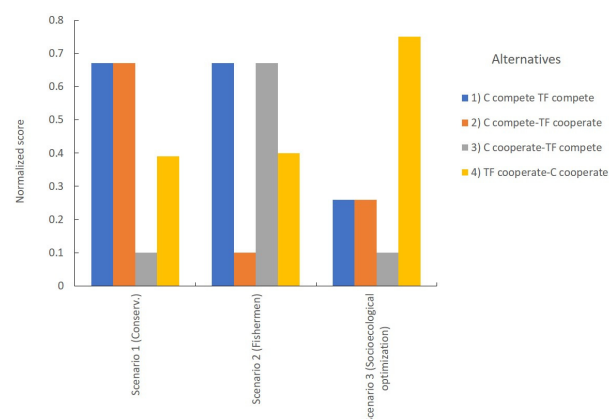
formed the analysis only taking into account this criterion, which was the most important taken into account by this sector during the decree process.

- Scenario 2 (tuna fishermen-oriented perspective): decision is taken just by avoiding the costs incurred by fishers of creating a no-take zone as fishing ground loss. We performed the analysis only taking into account this criterion.
- Scenario 3 (socio-ecological optimization): decision is taken with the criteria we propose as the minimum necessary to be considered in designing a network of no-take zones in a large marine reserve such as the one established around the Revillagigedo Archipelago.

With these criteria, we run Delphos in an evaluation matrix (Table 2) and plotted the rank of the four alternatives (Figure 5) according to the different criteria given by the agents in competitive and cooperative scenarios. This analysis is presented as the stag hunt game, whereby agents gain something by making decisions based just on their main interests, but not as much as they could have won by cooperating (Figure 5).

**Table 2.** Evaluation matrix (Tuna fishermen (TF); conservationists (C)).

		CRITERIA							
		No take marine reserve Benefit	Fishing ground loss Cost	Connectivity Benefit	Funds for conserving vulnerable species Benefit	Fishing over floating objects Cost	International political support Benefit	National political support Benefit	Alienation of potential partners Benefit
		km <sup>2</sup> of no take reserve	%	(1) None (2) Mediocre (3) With potential	Millions of USD	(1) Moderate (2) Strong	(1) None (2) Fast and brief (3) With potential to create allies	(1) None (2) Fast and brief (3) With potential to create allies	(1) Alienated (2) Collaboration
ALTERNATIVES	Alternative 1 (C Compete-TF Compete)	148,000	25	Mediocre	0	Strong	Fast and brief	None	Alienated
	Alternative 2 (C Compete-TF Cooperate)	148,000	25	Mediocre	0	Strong	Fast and brief	None	Alienated
	Alternative 3 (C Cooperate-TF Compete)	0	0	None	0	Moderate	None	Fast and brief	Alienated
	Alternative 4 (TF Cooperate-C Cooperate)	74,000	12.5	With potential	10	Moderate	With potential to create allies	With potential to create allies	Collaboration



**Figure 5.** Ranking of the three alternative scenarios.

#### 4. Discussion

This paper illustrates with a relatively simple and popular model of the prisoner's dilemma combined with a user friendly multicriteria program, the potential losses incurred by the conservation sector, the fishing industry and society as a whole for not implementing a cooperative strategy in the creation of LSMPAs. This perspective could be useful to understanding many conservation challenges society is facing to preserve wild marine environments; from the open ocean to coastal ecosystems, conservationists and fishers are likely to benefit from a cooperative strategy rather than a competitive one.

Our results illustrate that avoiding the dialogue with the fishing industry, one of the key actors in the pelagic environment and the high seas, when pursuing for a LSMPA, might bring some major unintended consequences to achieve an effective plan for marine conservation; in this case, the most conspicuous ones were pushing the fleet to fish over floating objects in the high seas, alienated further support from the new administrations, establishing a LSMPA with no funds to operate and allowing politicians to state that international conservation goals were achieved.

In this section it is important to highlight the pros and cons of mixing MCDA with prisoner dilemma models. Conventional prisoner dilemma models for fisheries and other economic problems use quantitative data to run and analyze scenarios [61] and even consider the prisoner dilemma and multicriteria analysis as mutually exclusive [17]. With our step-by step model proposed, we considered the stag hunt game as a suitable tool to illustrate how the conservation community might be trapped in a competitive game with the fishing industry in Mexico that could be applied elsewhere, which could be analyzed with future economic models. The use of Delphos helps illustrate how stakeholders can discuss alternatives of shapes for a network of no-take marine reserves, set criteria, negotiate weights and achieve cooperative scenarios where both conservation and fishing goals are fulfilled. Our suggested criteria did not attempt to be considered as a set that could be applied in other processes, but as a framework of the type of criteria that needed to be taken into account in a discussion of why and how a large marine protected area should be established.

One of the most interesting phenomena of game theory experiments is to study how agents change their behavior in interactive games over a period of time [62]. Cooperative behavior studies show that if agents have enough time to interact, they will end up cooperating because it benefits both parties in the end [62], in economic terms or with other more subtle values such as creating alliances, political support or just endorsement. Unfortunately, in the real world things occur at such a slow pace that it is almost impossible to forecast the evolution of cooperation. However, it can be stimulated by clear policies that recognize the benefits of cooperation.

What is behind the rush some academics and international NGOs seem to have to protect the oceans no matter how? To put it into the language of the evolution of cooperation, in the current model of economic growth both on land and at sea the industry has acted against people in a competitive way, maximizing their private benefits at the expense of public goods. No wonder we have destroyed the climate's delicate balance or why 90% of large marine vertebrates have been wiped out [63]. With the same approach used by the industry lobbying, lack of transparency and using top-down strategies, today some conservationists are trying to protect and save whatever is left in the wild marine environment.

A recent study shows that more than 91% of a group of marine protected areas studied on a global scale lack sufficient resources and staff to be properly managed, and that both staff and budget capacity were the strongest predictors of conservation performance [64]. In weak states such as Mexico, politicians have a very strong incentive to create 'paper parks' during their term in government because they know it will not be their responsibility to secure funding for them. After signing these decrees, politicians normally receive recognition from the international community, who even go as far as to call them "champions". The great loser of this power game, as this paper reveals, is society as a whole.



Political geographers state that boundaries are socially constructed concepts to define “us” and “them” [65]. This definition is key to understanding who should be involved in preserving the goods and services the ocean provides society with. The fewer “we” are, the less opportunities we have to invest time and money in making sure ecosystem services are maximized to benefit society as a whole. The construction of the European Union implied a dilution of each country’s territories and boundaries to promote cross-border cooperation. In the same way, when referring to the marine environment, the more we dilute the borders between the people who are willing to preserve the ocean’s biodiversity and the people who are actually using it, the more opportunities we will have to cooperate towards more effective and sophisticated solutions. In this sense, the fishing industry could be one of the most important allies to promote well-preserved, thriving and productive marine environments.

Human cooperation has been one of the most challenging puzzles for nature conservation [66]. Georgina Mace from University College London has recently revised the history of how our scope to promote nature conservation has evolved over the past fifty years, from thinking back in the 1960s that biodiversity should be kept in almost untouched and isolated refuges all the way to understanding over the last decade that people and nature should coexist in shared spaces with the wide use of the socio-ecological system concept [67]. Our advice for large foundations and NGOs promoting large marine protected areas on a global and local scale is to ensure their strategy addresses this evolutionary path of cooperation and to take advantage of cooperative strategies to truly secure marine conservation in a changing world.

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