Marine Policy 73 (2016) 154–161

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Fish banks: An economic model to scale marine conservation

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ARTICLE INFO

Article history:
Received 24 February 2016
Received in revised form
31 July 2016
Accepted 31 July 2016

ABSTRACT

Only 2.1% of the ocean is in actively managed marine protected areas (MPAs). Achieving the United Nations' target of 10% of the ocean protected by 2020 will require an aggressively implemented mix of large MPAs in remote areas, and small MPAs in inhabited coastal areas. Replication of small no-take MPAs (marine reserves) in coastal areas at the global scale is more likely to occur if reserves are designed as investment opportunities – ‘fish banks’ that produce new profits based on ecosystem services such as tourism and fish production. Here a pro forma business plan for a marine reserve using private investment and local management is presented. Total annual profit before the reserve was €254,000 (from fishing only); in year 8 after creation of the reserve, profit (fishing+tourism) was €3.3 million. Given the right conditions, the net present value of the reserve can be between 4 and 12 times greater than the no-reserve counterfactual. In our model, (1) the tourism sector covers the costs of creation and operation of the reserve as an investment in a profitable business; and (2) fishers become shareholders and receive income from tourist access fees; their profits increase as soon as one year after the creation of the reserve. A series of financing mechanisms to create and manage fish banks is also proposed. If designed properly, fish banks can help restore marine biodiversity and ecosystem services, and can create jobs, help fishers, and bring in significantly greater economic profits than the absence of protection.

1. Introduction

While 14% of earth's land surface is protected from extractive use, only 2.1% of the ocean is in actively managed Marine Protected Areas (MPAs) (Fig. 1). Declines in many of the world's fisheries, combined with threats from invasive species, pollution, and ocean acidification recently led the parties of the UN Convention on Biological Diversity (CBD) to set a target of 10% of marine and coastal areas protected by 2020 (Aichi Biodiversity Target 11 [1]). How will this ambitious target be met? It could likely be achieved through a combination of tens of thousands of small marine protected areas (MPAs) in inhabited areas, and a smaller number of very large MPAs (100,000 s km^2 each) in remote places. Creation of very large no-take marine reserves such as Chile's Nazca-Desventuradas Marine Park and the U.S. Pacific Remote Islands Marine National Monument will boost the percentage of the ocean protected. However, there is no commonly-adopted formula for replicating small-scale, locally-endorsed marine reserve successes to the global scale. Here a business approach whereby marine reserves can be created and managed locally through private investment is proposed. This approach will rely heavily on no-take marine reserves, which have shown the biggest ecological and economic benefits caused by the restoration of ecosystem services [2,3] (in addition to partially-protected MPAs).

No-take marine reserves can act like financial investments with a principal set aside that produces interest, if they are well

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http://dx.doi.org/10.1016/j.marpol.2016.07.032
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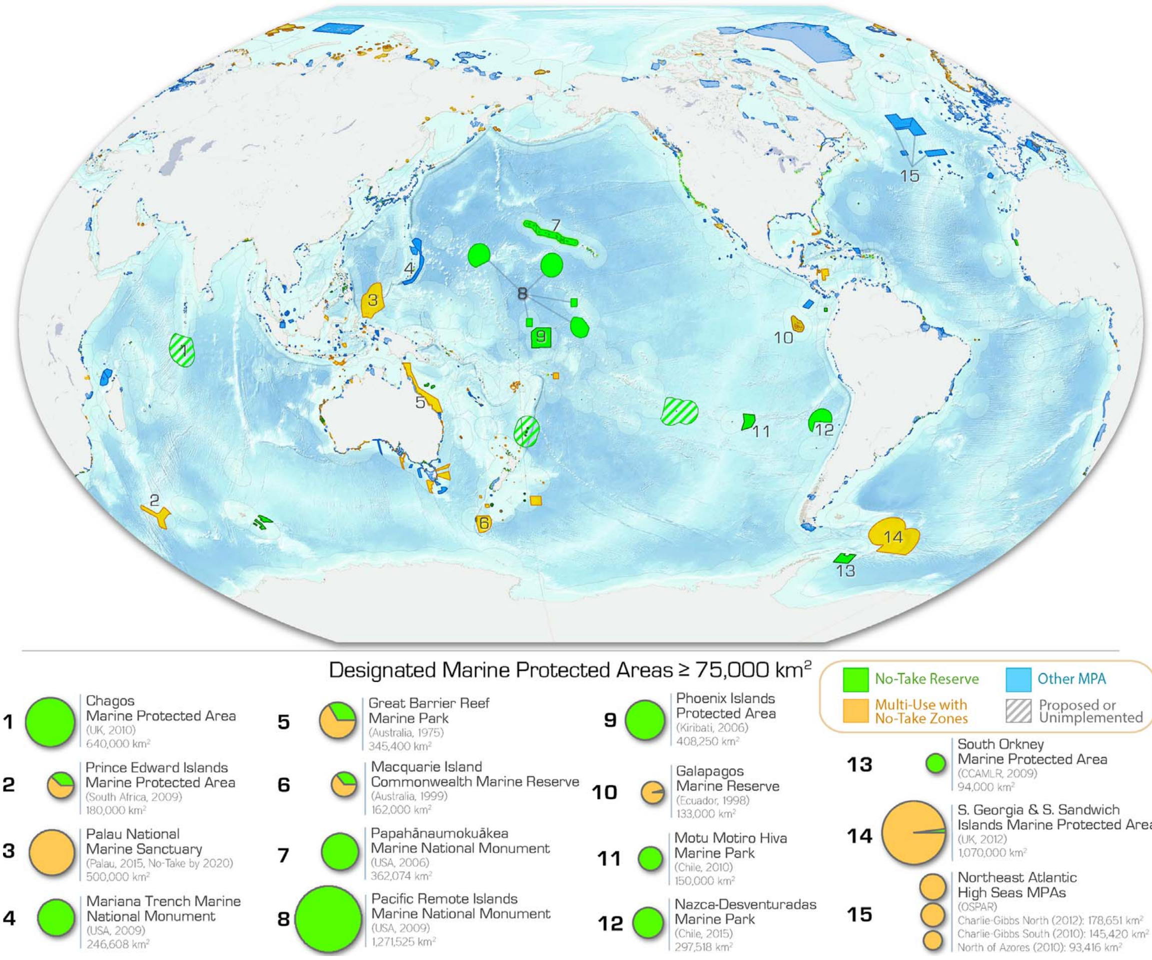

Fig. 1. The marine protected areas (MPAs) of the world: partially-protected MPAs (orange areas), no-take marine reserves (green), and other protected areas (e.g., protected on paper but with insufficient legislation or enforcement; blue). Currently 2.1% of the ocean is in marine protected areas *sensu lato*, and only 1% of the ocean is in no-take marine reserves (mpatlas.org). The 15 largest MPAs that have been implemented are highlighted. It would take 17,600 more average-sized MPAs to achieve the UN Convention on Biological Diversity target of 10% of the ocean protected by 2020. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

designed and managed. Marine reserves result in an average increase of 446% in fish biomass within a decade, relative to unprotected areas nearby [2]; the restoration of ecosystem services such as fish production (through spillover of fish and invertebrates) that can benefit the adjacent fishing industry [4,5]; and increased biodiversity that can attract more tourism, producing up to 36 times more revenue than fishing [6]. In addition, the protection of coastal ecosystems preserves important ecosystem services such as efficient carbon sequestration [7], coastal protection from storms [8], and replenishment of local fisheries [9].

Why have these bright spots not been replicated globally? The main reasons are lack of awareness among stakeholders, inappropriate governance, and unsustainable funding models. Because protection often results in short-run losses and fishers lack secure and exclusive access to the spillover from marine reserves (which are a local public good in economic terminology), fishers rationally choose the status quo over the prospect of better fishing opportunities and livelihoods within a few years.

By coupling institutional reform and private investment, marine reserves could be seen as 'fish banks' – an investment in future prosperity rather than a foregone economic opportunity. Empirical data show that the economic benefits of reserves can offset the costs of closure in as little as five years, in some cases doubling the income of local fishers [4]. An important consideration for any form of private investment involves securing the benefits of protection by providing exclusive access to local fishers, businesses, or communities [10]. Establishing these access rights ensures that a community benefits from its own conservation actions, thus securing a platform for investment by other actors. Here a pro forma business plan is developed to show how to implement fish banks and capitalize on the ecosystem services they provide, and describe some financing mechanisms to create and manage fish banks.

2. Material and methods

The creation of a marine reserve was modeled, exclusively with private investment, and managed by a local entity of shareholders (fishers and tourist operators), using empirical data from the Medes Islands (see below). For simplicity our model considers only 'ecotourists' who visit the reserve to dive, snorkel, and/or tour the reserve on glass bottom boats, as the new source of revenue (though fishing remains a revenue source). In our model, all ecotourists pay a reserve access fee (as opposed to only scuba divers currently); fishermen receive a percentage of these access fees as compensation for foregoing a fraction of their traditional fishing grounds; and the tourism industry covers the establishment of the reserve and part of its management costs, since they are likely to be the ones to benefit the most economically. Tourist activity increased over time after the creation of the reserve, and the analysis captured their gradual increase, starting in year 0 when the reserve is created and the management structure is put in place; tourism starts to arrive on year 1 after the creation of the reserve (Table S1). Costs, revenues and profits were calculated for the first eight years after the creation of the reserve, when the total number of dives in the reserve reached equilibrium at the maximum allowed quota [4]. Finally, the Net Present Value (NPV) of the reserve over an 8-year time horizon was calculated under different scenarios of protection and compensation, for both tourism industry and fishers.

The Medes Islands Marine Reserve was protected in 1983, and tourist numbers increased as fish size and abundance increased within its boundaries [4,11] (Table S1). The three main operations bringing tourists to the Medes Islands Marine Reserve are diving centers (carrying scuba divers and snorkelers) and glass bottom boats. There are two types of diving centers: "small", with large semi-rigid inflatable boats carrying up to 12 divers at a time; and "large" dive centers, with larger fiberglass or wooden boats carrying up to 25 divers at a time (E. Sala, pers. obs.). A much smaller number of divers also visit the reserve using private boats, and they pay the same access fee as divers using dive centers; for simplicity of this analysis, all divers were pooled together as though they were all using dive centers.

Implementing a reserve can represent a cost to fishers due to the loss of part of the fishing grounds. Costs for the tourism industry are the capital outlay for establishing their operation plus the management costs of the reserve. The costs of establishing and running diving centers and glass bottom boats are detailed in Table S2, and were estimated after interviews with local business owners, and after E. Sala's experience working for over a decade in the marine reserve. The initial establishing costs of the reserve include renting an office and visitor welcome space, diving gear, and a surveillance boat; the management costs include salaries and supplies [11] (Table S3).

Revenue from ecotourism was based on empirical data from the Medes Islands Marine Reserve in 2009 [11]: each diver pays an average of 25 Euros per dive, a snorkeler pays 30 Euros per visit (more than scuba divers because they hire a guide and tend to rent equipment), and glass bottom boat users pay 22 Euros per trip (Table S4). Currently only scuba divers pay reserve access fees (4 Euros per dive). In our model, snorkelers and glass bottom boat users also pay 3 and 2 Euros per visit, respectively.

Our model assumed that tourism operators and fishers invested in a novel joint venture, where a percentage of the tourist access fees is transferred to fishers. The model considered transferring from 0% to 100% of the access fees to fishers; the remaining percentage of the access fees offsets the management costs of the reserve. For example, if 10% of the access fees go to fishers, the remaining 90% offsets the management costs for the tourism industry; if 100% of the access fees go to fishers, the tourism industry has to cover all of the management costs.

Profits for fishers are the fishery profit plus the revenues from tourist access fees (which represent no cost to them since the reserve management collects them). The model assumed a baseline of stable fishery profits under the scenario of no protection; this is a conservative scenario since local fisheries in Mediterranean coastal areas are typically declining over time. The bioeconomic model [4] also assumed that the fishing effort from the protected fishing grounds was not displaced to the surrounding unprotected grounds, so that total fishing effort in the region is reduced proportionally to the percentage of the fishing grounds that become protected. Profits for the tourism industry are tourism revenue (Table S4) minus the above costs. All economic values are adjusted for inflation.

The Net Present Value of the reserve was calculated as (Eq. (1)):

$$NPV = \sum_{t=0}^{T} \frac{\pi_t}{(1+r)^t} \quad (1)$$

where t is the year, and $t=0$ is the year of creation of the reserve (there is no tourism yet); T is the timeframe for which NPV is calculated (8 years in our case); π is profit; and r is the discount rate (we used 7% since typical discount rates for environmental projects are between 4 and 8%).

To explore what could be the economically ideal size of the reserve for both tourism industry and fishers our model used an extension of Sala et al.'s [4] bioeconomic model. The model assumed conservatively that costs and revenues (for tourism and reserve management) would increase linearly with an increase in the area protected. The simulations started with the current reserve size of 10% of the fishing grounds protected, and assumed that doubling the size of the reserve would result in a 25% increase in the number of visitors. Therefore, closing all fishing grounds (that is, multiplying the reserve size times ten) would result in a 125% increase in the number of visitors. That means 150,750 scuba dives in an area 10 times larger than the current reserve (which actually receives 67,000 dives per year). This is a very conservative estimate, because before the current quota of 67,000 dives per years was established, there were about 100,000 dives per year within only 10% of the fishing grounds [11]. Our model assumed that costs and revenues would also increase linearly with the number of visitors. This is also a conservative assumption, because costs of marine reserve establishment and management per surface area have been shown to decrease with reserve size [12]. Changes in NPV for each tourism and fishing under increasing sizes of the marine reserve were then modeled, and the maximum total NPV (fisheries+tourism, and separately) calculated.

3. Results and discussion

There is increasing evidence that fishers can benefit from marine reserves after a few years [4], but the lack of financing during those build-up years has been a major factor in preventing the scaling of marine reserves worldwide. Faced with this dilemma, our new business model explores whether marine reserves could bring sufficient revenue to pay for themselves, finance short-term losses, and turn in a profit.

3.1. A business plan to capitalize on ecosystems services

The Medes Islands Marine Reserve, Spain, has a small no-take area (about one square kilometer) with one of the largest biomass of fish in the Mediterranean [4]. This benefits fishermen through fish spillover [4,13], and supports an ecotourism operation that brings €10 million to the local economy annually, mainly through diving, snorkeling, and glass bottom boats [11]. The regional Catalan Government created the reserve in 1983, after a long process and general opposition from commercial and recreational fishermen. The management costs of the reserve have been covered with public funds, and all the tourism profit generated by the reserve has remained in private hands. The only revenue generated by the reserve that is reinvested in the reserve itself is the access fees paid by scuba divers, who bring in €235,000 per year, covering about half of the management costs of the reserve [11]. A recent study indicated that the reserve value exceeded the pre-reserve value in only five years, but this analysis considered only fishery profits and scuba diving revenue under the current size of the reserve [4], and ignored other economic benefits.

Our model used empirical data on increases in diver numbers, costs and revenues of the Medes Islands reserve (Tables S1–3),

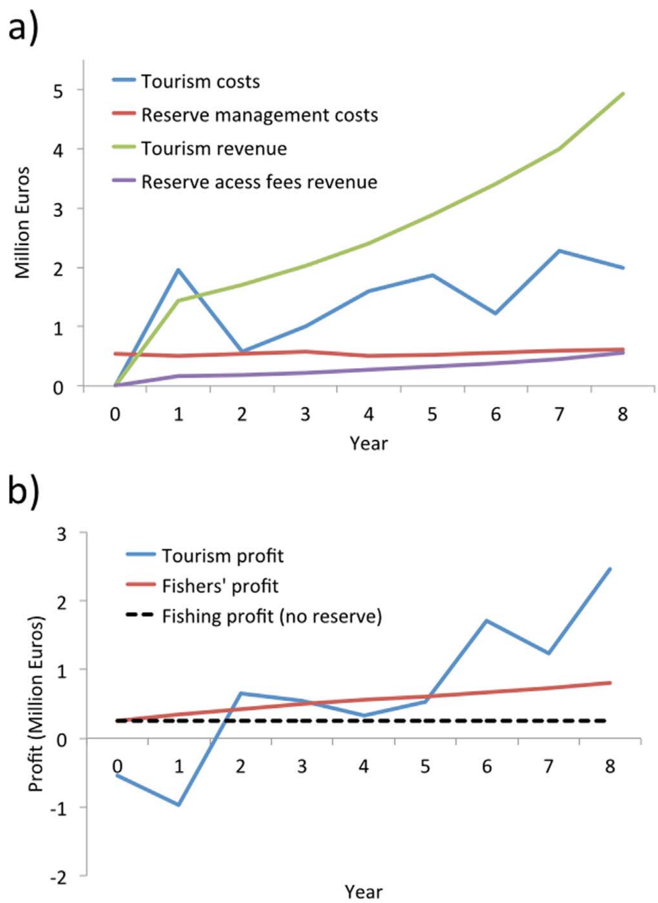

Fig. 2. Changes in a) costs and revenues at the Medes Islands Marine Reserve at its current size (94 ha, or 10% of the area protected) on a 8-year time frame, and b) tourism and fishing profits at its current size, where 75% of tourist's access fees are transferred to the fishers (see Fig. 4). Year 0 is the year of creation of the reserve. The baseline is the no-reserve situation with only fishing profit.

together with a bioeconomic model [4], to develop a pro forma business plan for the reserve under a range of scenarios. The model assumed that in the year of creation of the reserve (year 0), the tourism industry incurred only costs (they raised no revenue), and that tourism began one year after the creation of the reserve (Fig. 2a, Table S1). Costs of developing the infrastructure for tourism (Table S2) fluctuated over the first eight years because the number of diving centers and glass bottom boats did not occur at once, but grew organically as a function of the increasing number of visitors (Table S4). The revenue from visitor access fees to the reserve reached €554,000 by year 8 (when number of visitors peaked at 151,333; Table S1), and almost equalled the annual management costs of the reserve at that year (€614,383) (Fig. 2a). By year 8, tourism profit was €2.5 million, over 4 times the management costs of the reserve (Fig. 2b). Under the current reserve size, if 75% of the tourist's access fees were transferred to the fishers (see below and Fig. 4 for rationale), fishers would never experience any economic loss from the reserve. The tourism sector would start experiencing net annual profit by year 2 after the creation of the reserve.

Our results show that without the reserve, and assuming that fishery profits will not decline over time, the Net Present Value (NPV) of the fishing grounds for fishers is €1.8 million (Fig. 3). NPV with a reserve and tourism activity is greater than the unprotected alternative under any reserve size. Under the current situation of 10% of the area protected, NPV varies between €5 and 8 million for discount rates between 5 and 12%; if the entire area were protected, NPV would range between €17 and 25 million.

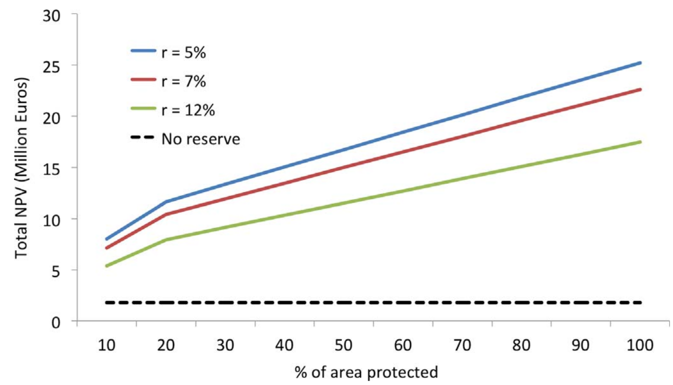

Fig. 3. Changes in total Net Present Value (NPV) of the Medes Islands Marine Reserve (fisheries+tourism) at its current size (94 ha, or 10% of the area protected) and increasing sizes (up to 10 times larger, or 100% of the area protected), under three different discount rates (*r*) on a 8-year time frame. The value of the fishing grounds left unprotected (where only fishery profits are realized) is shown as a no-reserve baseline.

If the model is constrained to the current reserve size, and a distribution of tourist access fees is chosen to provide profits for both fishers and tourism industry, this occurs when fishers receive 75% of the tourist access fees (and thus the reserve management costs for the tourism industry are offset by 25% of the tourist access fees) (Fig. 4). Under this arrangement, the NPV for each fishers and tourism industry is €3.5 million, which is substantially higher than the no-reserve value of fisheries alone. Fishers not only can continue fishing around the reserve (with less total effort), but also their profits nearly double because the profits from tourist access fees offset the losses due to protection. Under this scheme, there is no financial disincentive for the fishers to agree to create a reserve. However, we again highlight the importance of local access control. If fishermen from outside the agreement ('free riders') are freely allowed to enter, they could (1) increase effort outside the reserve thus reducing the reserve's benefits, (2) potentially challenge the creation of the reserve (since they would hold no financial stake in its benefits), and (3) may pose a higher poaching risk than insiders. Therefore, a legally-binding agreement between stakeholders/shareholders is imperative, and also that the local government legislates and enforces exclusive access rights to local stakeholders.

Our model also explored the ideal size of the reserve for both fishers and tourism industry. Larger reserves allow more biomass to build up and thus attract more tourists, but also reduce the fishable area. In the Medes Islands, if reserve size could be changed to increase total aggregate benefits, the scenario that maximizes economic value is to protect 100% of the fishing grounds, and for fishers to receive 100% of the tourists' access fees (Fig. 4). The resulting NPV for fishers is €4.3 million, and NPV=€18.3 million for the tourism industry. Overall, the reserve has an aggregate NPV=€22.6 million for the first 8 years after its creation relative to the alternative NPV =€1.8 million without any protection. Fishers are better off economically with more protection under most scenarios, as long as they receive more than 50% of the tourist access fees.

Our model also tested whether changes in tourism demand would affect the economic performance of the reserve. To conduct this experiment, the model assumed a downward shift in the tourism demand curve and to keep things simple, the model assumed that the reserve managers consequently reduce price such that the number of visits remains constant. Under its current size, the NPV of the reserve would still be greater than the no-reserve scenario under a 20% decline in prices paid by tourists for visiting the reserve (Fig. 5). If tourist prices were 50% lower, NPV would be greater than the no-reserve scenario only if more than 50% of the

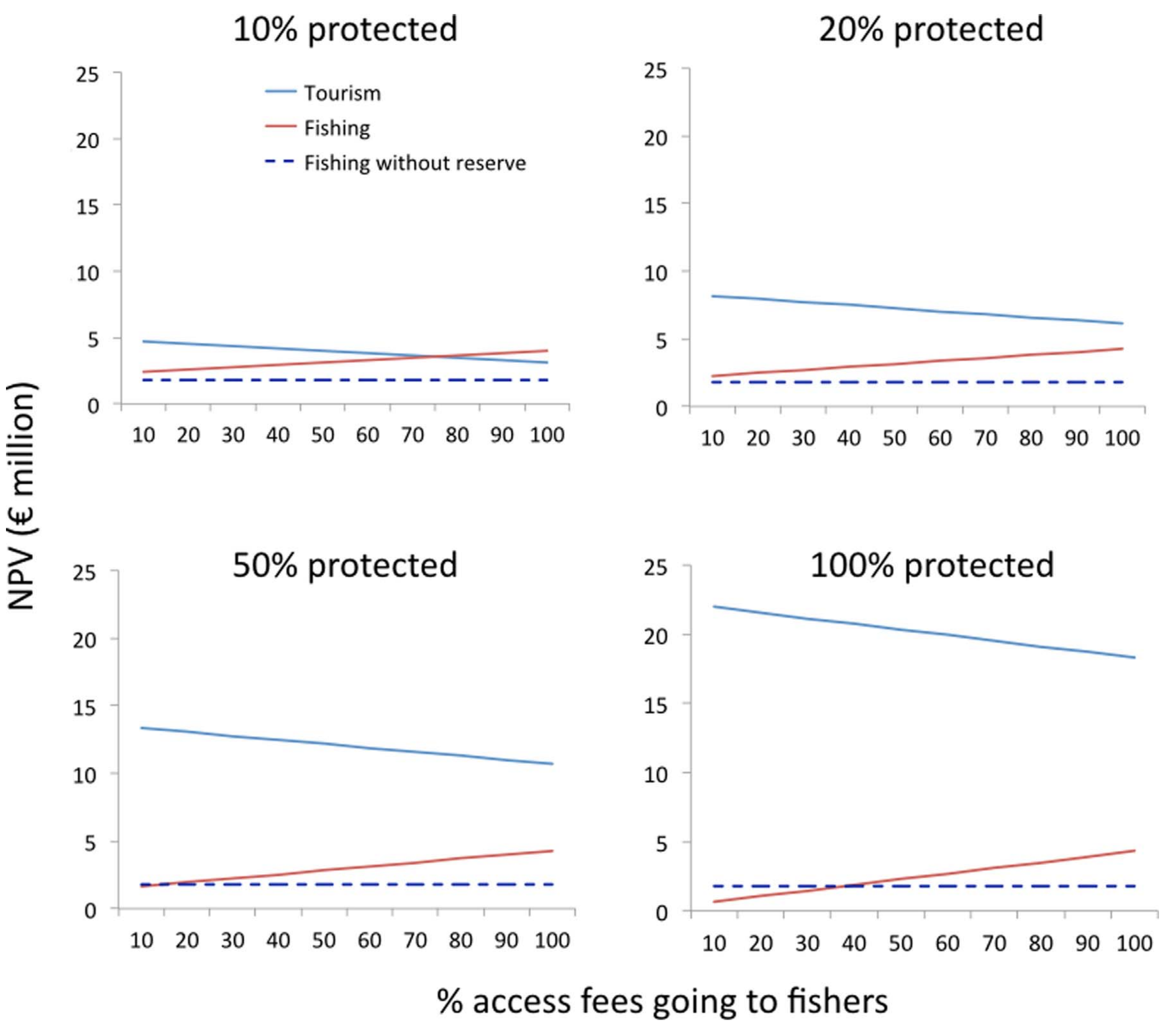

Fig. 4. Changes in Net Present Value (NPV) of the Medes Islands Marine Reserve at its current size (94 ha, or 10% of the area protected) and increasing sizes for fishers and tourism industry, along a range of 'compensation' fees for fishers (percent of access fees paid by eco-tourists visiting the reserve that are received by fishers). The value of the fishing grounds left unprotected (where only fishery profits are realized) is shown as a baseline. NPV was calculated on a 8-year time frame, with an assumed discount rate of 7%.

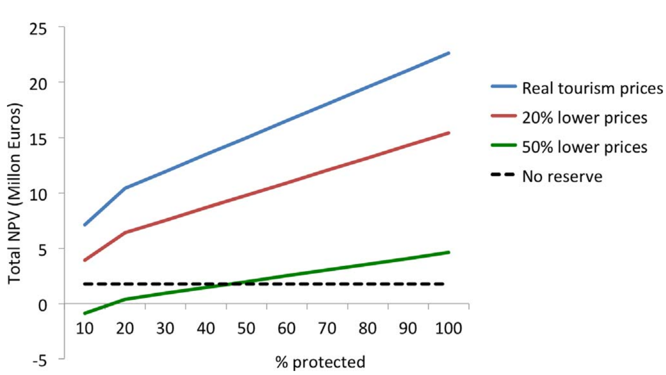

Fig. 5. Changes in total Net Present Value (NPV) of the Medes Islands Marine Reserve (fisheries+tourism) at its current size (94 ha, or 10% of the area protected) and increasing sizes, under different assumptions of the value of visitation of the reserve. Real tourism prices are the actual 2009 prices. The value of the fishing grounds left unprotected (where only fishery profits are realized) is shown as a baseline.

area was protected. This suggests that small marine reserves can be economically beneficial to all if visitation prices are reasonably high; but if prices were too low, increasing the NPV of the reserve would require an increase in the volume of tourists. However, a 50% decline in tourist prices is unlikely because of the high demand for visitation of the reserve.

These results are remarkable for a no-take reserve that is currently only 94 ha (0.94 square kilometers) in size, and which would be 940 ha if protection increased by ten times as in the scenario of all fishing grounds protected. Both under the current reserve size and after reserve expansion, the profits generated by tourism (immediately) and the enhanced fishing due to spillover (after five years) far offset the costs of protection and short-term losses to fishers due to the reduction of their fishing grounds. Furthermore, these are conservative estimates, since our assumed revenue is only half of what was actually estimated for the Medes Islands Marine Reserve in 2009 [11], and other economic benefits such the multiplier effects of restaurants, lodging, transportation, and other services were not included [14]. The time-horizon for estimating NPV is only 8 years because this is the time it took to achieve the maximum number of divers in the reserve, but longer time horizons would yield greater values. Our model also assumed that fishing effort was not displaced outside of the protected area after the creation of the reserve, and that local fishers have exclusive access rights to the fishing ground surrounding the reserve [15,16].

In this example, fishers are realizing the benefits of protection so quickly after the creation of the reserve because they are benefitting from an additional ecosystem service, instead of having to wait for fish spillover to occur as their only benefit. This additional benefit – the revenue from tourist access fees – is greater than the opportunity cost of creating the reserve and the related short-term lost fishing revenue. The Medes Islands might be a particularly successful example because, although it received little diving before the creation of the reserve in 1983, it had the right conditions for the development of diving and glass-bottom boat business (e.g., easy access, basic tourism infrastructure). That is partly why it is the reserve with the largest concentration of scuba dives in the Mediterranean; other places may not have such potential profits from ecotourism.

The main reason that tourism profits are much larger than fishing profits in the Medes Islands is because it is one of the few well-enforced no-take marine reserves in the Mediterranean, and it harbors the second largest fish biomass in the region [17]. Poorly-managed reserves often do not result in increases in fish biomass [17,18], although merely labeling an area as "protected" has been shown to attract eco-tourists [19].

Would marine ecotourism increase in an area with more modest increases in fish biomass? And, would economic benefits be realized at the scale of the Medes Islands? There are many other places in the Mediterranean with existing tourism infrastructure but little or no diving because there is not much to see underwater. For instance, the extensive shores of Greece and Turkey are tourism hotspots, but they receive few divers because the abundance of marine life has been reduced to their lowest historical levels because of overfishing [17]. However, they have the potential of restoring their fish populations through no-take marine reserves, engage fishers, and help develop an incipient marine tourism, like around the recent marine reserves created in Gökova Bay, Turkey [20].

The fact that the number of dives had to be limited at the Medes Islands (because there were many divers and they were damaging the bottom fauna [11,21]) clearly indicates that there is a great deal of demand and not enough marine reserves to accommodate all these divers and visitors who wish to catch a glimpse of the Mediterranean of the past (and well-managed present). Therefore the potential for increased economic value due to new tourism associated with increased fish abundance in reserves is still large. Furthermore, this study modeled only a single reserve proposal. Matching the most appropriate financial instrument with the ecological and social context will be crucial to optimizing benefits from marine reserves. In any case, a combination of tourism and fishing profits could make fish banks attractive to all stakeholders.

3.2. Financing mechanisms

Why would the tourism sector agree to cover the costs of reserve management and agree to transfer tourists' access fees to fishers? In our business model, the tourism industry agrees to finance the costs of reserve management because they know that a well-managed reserve will increase fish biomass and thus the value of their business, relative to the unprotected alternative. As our model shows, the economic benefits for the tourism sector are greater than under the unprotected alternative for all modeled scenarios. Therefore, covering the costs of reserve management is an investment in their own business – and a better business proposition. By including fishers as shareholders in a joint venture, fishers become proponents of the reserve. However, this is a new business model that has very seldom been implemented, because stakeholders are typically not aware of the potential benefits, because of the lack of precedent and consequent risk-averse behavior by the sector, and because of the complexity of two usually unrelated groups (fishing and tourism) coming together to negotiate a shared business in a place. A neutral negotiator, mediator and assessor will likely be necessary in this business model for transparency and accountability. This type of private investment in nature conservation would also provide an incentive for local governments to legislate the creation of new marine reserves. We believe that the following mechanisms could help develop such private-public partnerships, and reduce the risk incurred by the tourism sector, which typically has been reluctant to play a dominant role in marine conservation.

3.2.1. Buyouts

Buyouts typically aim to reduce total fishing effort (in overexploited fisheries) or stabilize effort (in fully exploited fisheries). In this case, buyouts could be used to diminish resistance by fishers to the creation or expansion of the reserve. In the Medes Islands, some fishers may opt to leave the fishery and use the cash to move into other occupations, while others may opt to retain the exclusive access rights to the waters around the reserve. However, if not properly designed, buyouts can result in strategic behavior that ultimately results in no reductions in effective fishing effort [22]. Further, buyout programs may be difficult to implement in the developing world, in fisheries with poor compliance, or where entry cannot be effectively controlled.

3.2.2. Bonds and shareholding

A municipal or community bond could be established where cash from the bond is used to cover short-term losses from reserve creation (the 'investment' in the reserve). The funds could also be guaranteed by the Spanish government or the European Investment Bank. The assets would be owed and owned by the fishing and the tourism sectors. If fishers were interested in greater economic benefits, they could become shareholders of the new tourism industry – with a share proportional to the expected short-term loss of revenue due to protection – instead of only receiving the revenue from tourist's access fees to the reserve.

3.2.3. Insurance products

The uncertainty of future benefits can make risk-averse stakeholders reluctant to invest in marine reserves. Insurance can contribute to a solution by developing products to insure stakeholders in case the expected benefits from the marine reserve are not realized. A major role of insurance would be to decrease risk, which is a good fit for marine reserves. Insurance and reinsurance companies have developed products to reduce risk in agriculture, chiefly from weather-related and disease risks, which could be adapted to the fisheries around the Medes Islands marine reserve. In fact, this coverage already exists for fish farms in many parts of the world. Adapting it to the Medes Islands marine reserve would require a change to the current product, however, as the fish in farms are captive, while those around the marine reserve can come and go.

3.2.4. Ecosystem services payments

Benefits foregone are usually the largest cost of protection for ecosystem services. However, it has been shown that in coastal habitats, habitat conversion ends up being more costly than avoiding conversion [23,24] – and the value of current ecosystem services tends to be underestimated because it generally does not account for non-market values. In the Medes Islands, for example, the preservation of the sea grass beds within the reserve can be linked to carbon capture and storage services, primary production, and other ecosystem services [25], which have been estimated to a minimum of €283–513/ha/year . Although ongoing efforts to get carbon credits for the carbon storage of mangroves, sea grasses and salt marshes, such as the United Nations Framework Convention on Climate Change's Blue Carbon Initiative (http://thebluecarboninitiative.org) could result in large payments [26], they are not likely in the near future.

A further service that has been largely ignored or undervalued is the spawning function. The Medes Islands marine reserve has caused an increase over time in the size and biomass of commercial fishes, which has been associated to fish spillover to the neighboring fishing grounds exclusive to local fishers [27,28]. Since egg production increases non-linearly with fish size, the Medes Islands marine reserve acts as a savings account yielding compound interest. Local fishers with access rights to the fishing grounds around the reserve could pay for the reproduction service as a collective investment in their operation.

3.2.5. Tourism access fees

In situations where marine reserves are likely to result in ecotourism growth, access fees for tourists (e.g., divers) could be used to cover the costs of management of the reserve [29], and to finance the transition for fishers from open access to a system with reserves. In the Medes Islands Marine Reserve, half of the management costs are currently covered by access fees for scuba divers alone (Tables S3 and 4), but charging fees to other visitors as we propose in our model could cover all costs and still turn a profit – if fees were not transferred to fishers. For example, the Saba Marine Park in the Netherlands' Antilles is self-funded because of tourism revenue [30].

3.2.6. Seafood market development

The development of direct marketing of products associated with the marine reserve could allow fishers to stabilize profits and be another incentive for them to invest in the creation of the reserve. If fishers were well organized and markets were local, fishers would benefit because they can sell their catch at a higher price than what they obtain from seafood dealers. Consumers benefit because they obtain fresher, locally-produced, and equally or even less expensive seafood than what they find at the grocery store. Extra profit for the fishers could be gained if the fish caught around the marine reserve (which could qualify for an 'eco-label' certification) had a price premium. This scheme would work best if the consumer does not have to pay more than at the grocery store – although consumers have shown the willingness to pay price premiums in the order of up to 14% for 'eco-labeled' seafood [31].

4. Conclusions

Restoring marine life and the services and products it provides can be profitable using the right business model under the right conditions. Portfolios of the above financing mechanisms could help transition from open access or ineffectively managed common property regimes to a system with a fraction of the fishing grounds as 'fish banks,' surrounded by well-managed fisheries with clear access rights and well-managed tourism [15]. Revenue produced by successful marine reserves can cover the costs of management, making them self-sustaining while creating jobs, and profit. The pro forma business model using empirical data from the Medes Islands Marine Reserve suggests that fish banks can be created and managed by a local enterprise exclusively with private funding, especially in areas that already have basic tourism infrastructure. Public/private partnerships could make the deal still easier for everyone.

Perhaps the most efficient way to create fish banks is for governments to empower local communities by passing legislation that allows them to create and manage their own fish banks (like in the Philippines), and to provide public policy support for private investment (as in REDD+). Most importantly, a necessary condition for the creation of fish banks is that the fishing grounds around them be accessed exclusively by local fishers (often those with historical rights [15]); without clear access rights, even clear short-term economic benefits may be eroded and discounted by fishers. Fish banks could be the best way for people to have their fish and eat them too.

Acknowledgments

We are grateful to HSH Prince Albert II of Monaco, J. Capellà, B. Fautrier, J. Garrett-Cox, O. Happel, J. Jacquet, Y. Jarrar, B. Jenks, M. Jorge, A. Loesekrug-Pietri, P. McWhinney, J. Murray, O. Oullier, B. Oymen, P. Patil, L. Schlesinger, N. Schwab, D. Shapiro, the Young Global Leaders' Fish Banks Task Force, and the participants of the "A New Ocean Economy" event at the World Economic Forum, for discussions and suggestions. Thanks to L. Pendleton who greatly improved a previous version of this manuscript. This study was supported by the Waitt Foundation and National Geographic Pristine Seas.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.marpol.2016.07.032.

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