

POLICY PERSPECTIVE

Endangered Species, Ecosystem Integrity, and Human Livelihoods

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Abstract

If efforts to conserve endangered species lack long-term visions and neglect the human dimensions, conservation success will be questionable. Exclusion of stakeholders in decisions can lead to mistrust and polarization of groups. The story of the vaquita marina (*Phocoena sinus*) in the Upper Gulf of California provides a unique opportunity to discuss this paradigm. A proposed gear-switch in the local fisheries addresses the bycatch that threatens the vaquita but neglects local livelihoods, the traditions and heritage of the community, the ecological integrity of the area and increases dependence on fishing subsidies. We estimate it will cost an additional US \$8.5 million (2/3 of the net revenue produced by gillnets and 30% more in fuel consumption) if local revenues are to be maintained at pre-gear-switch levels. In addition, suggested new trawl gears caught 2.7 times more unusable (therefore discarded) bycatch than gillnets, which included invertebrates and small juvenile fishes of economically valuable species. Our results show that the proposed gear switch intervention can be considered another “quick-fix” intervention in the history of the vaquita conservation agenda that urgently needs long-term goals that incorporate ecological, economic, and human wellbeing.

Introduction

What are the ecological and social impacts of efforts to conserve charismatic species that face the imminent threat of extinction? This is one of the most important questions in environmental conservation practice and policy (Sutherland *et al.* 2009), and the answer has significant implications for global conservation management. Existing conservation model frameworks (Bulte & Horan 2003; Barrett *et al.* 2011; McNally *et al.* 2011) often identify the relationships between ecosystem services and the importance of including stakeholders and authorities in the planning processes of protecting and/or exploiting these services (Lynam *et al.* 2007; Bauch *et al.* 2014; Rassweiler *et al.* 2014). It is, however, still challenging to use single-species strategies to find a balance between

restoring their populations, protecting ecosystem integrity, and maintaining human wellbeing in the region where the species exists. When resource extraction combines with bad management, it can drive a situation of radical conservation actions, which is nowadays a somewhat common paradigm in conservation texts (Gjertsen & Niesten 2010; Walston *et al.* 2010; Duffy 2014; Duffy *et al.* 2015), and makes future collaborations between extractive and conservation sectors increasingly difficult.

The story of the critically endangered vaquita (*Phocoena sinus*) offers the extraordinary opportunity to discuss this paradigm of radical conservation action in order to save a species at risk. The vaquita is endemic to the Upper Gulf of California (UGC) and it is now the world's most endangered cetacean (Rojas-Bracho *et al.* 2006). The history of vaquita conservation is long, complex, and began

following reported bycatches in the totoaba (*Totoaba macdonaldi*) fishery in the early 1960s (Vidal 1995) once the vaquita was first described (Norris & McFarland 1958). After the official closure of the Totoaba fishery, the focus of vaquita bycatch moved to the UGC's shrimp gillnetters (D'Agrosa *et al.* 2000) and, in 1993, the Upper Gulf of California and Colorado River Delta Biosphere Reserve was established (McGuire & Valdez-Gardea 1997; Rojas-Bracho *et al.* 2006; Morell 2008).

Predictions that only 59 vaquita are left (CIRVA 2016) and the continuing declines (CIRVA 2015) have increased pressure on the Mexican government that passed a law in 2013 to replace all shrimp gillnets with small trawling nets by the end of 2016. Government reports suggest these trawls are 100% vaquita-safe (INAPESCA 2014), whereas other reports demonstrate that fish and invertebrate bycatch ratios are more than is considered legal in the biosphere reserve (7:1 kg bycatch to shrimp; Calderon-Aguilera 2011).

Continued public and conservation-sector pressure have more recently lead to the announcement of a 2-year emergency gillnet ban throughout the vaquita's distribution, which began in May 2015 (DOF 2015). Additional strategies include: (a) buy-out and fishing gear switch-out programs, which have received around 40 million dollars (US) in the last 7 years and (b) increases in the budget for enforcement activities (Rojas-Bracho *et al.* 2006; Barlow *et al.* 2010). The impact of these management actions has polarized opinion among local communities and created a large rift between the fishing and conservation sectors (McGuire & Valdez-Gardea 1997; Barlow *et al.* 2010; Rodríguez-Quiroz & Aragón-Noriega 2013). This divide has been worsened by the exclusion of fishers from the formation of the new conservation measures, including the design of the new government trawls and gear tests, while expecting collaboration for data collections using this gear. The majority of knowledge used in the management and conservation of the UGC has come from western science and has had a disproportionate effect on social, cultural, and economic structures locally (Klein *et al.* 2015; Cisneros-Montemayor & Vincent 2016), wasting significant, useful information that the fishers' knowledge can provide for the design of management decisions (Hilborn 2007).

Here, we quantitatively evaluate the new suggested management plans and discuss how a lack of collaboration between conservation and extractive sectors reduces the possibility of successful future management scenarios. We demonstrate how increasing conservation pressures with a lack of collaboration between sectors can repeatedly lead to last minute efforts, which do not address the wider issues associated with saving endangered species.

Subsidies to maintain fishery profits

Following the widespread opposition by fishers to the long-term phase-out of gillnets, a period of gear testing was ordered by the Mexican government to estimate compensation costs. From August 18 to September 18, 2013, the Mexican Fisheries Institute (INAPESCA) conducted experimental gear tests as described in the Supplementary Information. Using all fishing trips ($n = 326$), we described summary statistics for the three fishing gears tested in the experiment, and based on current ex-vessel prices of landed catch and fuel prices, we estimated the overall value of the fishery and the cost to the government in terms of subsidy provision.

We found significant differences in the amount of shrimp caught by the different fishing gears (Figure 1). Gillnets caught an average of 3.2 times more shrimp than the RSINP trawlers (ANOVA $P < 0.001$), which caught a similar amount to the modified trawler nets ($P = 0.83$; Figure 1A). Gillnets covered an area 1.89 times larger than both trawler types ($P < 0.001$) and the biomass of shrimp per unit area was significantly higher (0.9 kg vs. 0.4 shrimp per km²) for gillnets than the trawlers ($P < 0.001$; Figure 1B). Gillnets caught more incidental (usable) bycatch (total kg) in the form of adult marketable fish than the RSINP trawlers ($P < 0.01$). In contrast, both kinds of trawls caught 2.7 times more unusable (therefore discarded) bycatch ($P < 0.001$) that included small juvenile fishes (< 10 cm) and juvenile invertebrates (Figure 1C). Both types of trawlers spent almost 30% more fuel per working trip ($P < 0.001$) than trips fishing with gillnets (Figure 1D).

We estimate that in previous shrimp fishing seasons (2011-'12, 2012-'13), each boat caught an average of 27.4 kg of shrimp per trip (± 0.7 SEM, $n = 1,221$ monitored fishing trips), a higher value than the 18.5 kg average obtained in the trips during the seasons from 1995 to 2002 (Perez-Arvizu *et al.* 2009). Based on an estimate of 645 boats with shrimp fishing permits in both communities, an average ex-vessel price of US \$12.41 (± 0.09 , $n = 1,128$) per kg of shrimp, and an average of 100 trips per boat per season (Perez-Valencia *et al.* 2012), the gross revenue of this fishery inside the reserve is approximately US \$21.78 million dollars. Taking into account the capture efficiency of the RSINP trawlers, and with 50% of the revenue from gillnets used for the costs of each trip, we estimate that the Mexican government would have to subsidize two thirds of the net revenue (US \$10.89 million * 0.66) from the shrimp fishery (close to US \$7.20 million dollars annually), to allow fishers to make the same earnings as they did previous to the proposed gear switch.

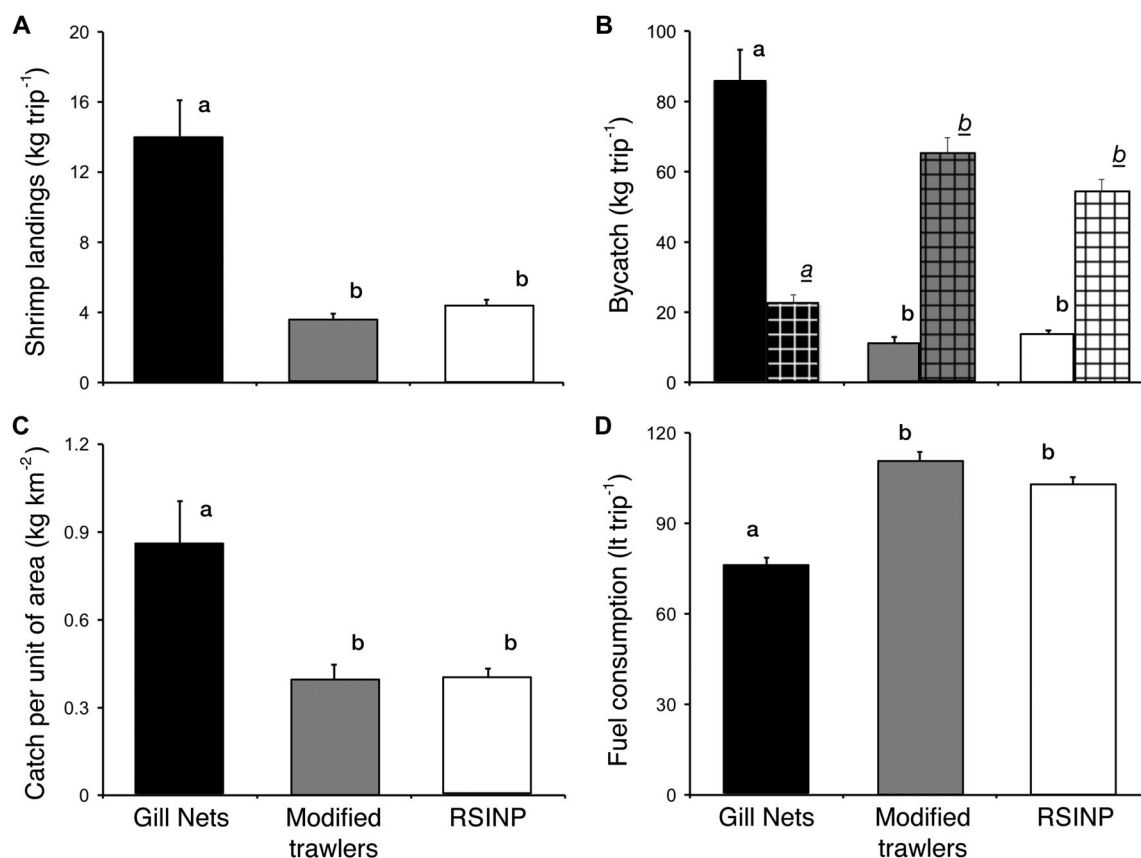


Figure 1 Average values (\pm SEM) of variables selected in the fishing gear-testing period in order to estimate compensation costs to cover economic losses incurred by the use of trawling nets in place of gillnets in the Upper Gulf of California shrimp fishery. Bars that share a letter within each plot are not significantly different from one another. In the bycatch figure (c), solid bars represent usable bycatch, hatched bars represent discarded bycatch and significance for each is marked with plain versus underlined letters.

The cost of fuel needed to operate the entire shrimp fleet using gillnets during the fishing season equates to approximately US \$4.45 million dollars (calculated based on #boats \times #trips \times average fuel used per trip \times price per liter). Because the average fuel consumption of the RSINP trawlers is 30% higher per trip, the Mexican government would need to subsidize the fishery an additional US \$1.33 million dollars annually, assuming the fishers only fish with the RSINP trawls three times per day.

The need for a new paradigm

The behavior of “quick-fix” type management, in which longer-term environmental degradation is not addressed, vast sums of money are invested, and social well-being left unconsidered is by no means sustainable. Short-term solutions that have developed in response to a crisis situation are particularly ineffective for a species whose life-history spans decades, such as the vaquita. Our results show that the proposed gear switch intervention

does not provide the fishers with a viable future livelihood, compared to their historic fishing activities. Successful management, however, should be focused on longer-term goals with minimal or zero governmental subsidies (Sumaila & Pauly 2007), and no additional risk to the integrity of local ecosystems.

With increasing pressure from environmental groups, conservation has been favored over the fishery and local economies in the UGC; which overall represents a short-sighted conservation approach that has characterized the history of the region. The combination of conservation versus fishery extremes, in conjunction with a consistent lack of collaboration between such groups, has led to the current difficulties in which management options have been significantly reduced. Local fisheries and livelihoods have been jeopardized and the situation of restoring the vaquita population is questionable due to the likelihood of noncompliance following a reliance on subsidies. This has exacerbated illegal fishing within local protected areas and outside of official fishing seasons (Platt 2014),

as well as incentivized the continued illegal fishing of the totoaba (Haro Cordero 2016) that, through bycatch, negates the current gillnet ban and continues to threaten the vaquita's survival. Below we first discuss the fisheries-economic, single short-term approach and the outcomes that have resulted so far. We then discuss some ideas related to longer-term visions involving the education and wellbeing of locals, which the authors believe is necessary to break the vicious cycle.

The short and narrow vision

The 2-year gillnet ban may benefit the conservation of the vaquita for 2 years, but there is no guarantee it will not revert back to the pre-ban "norm" of continued bycatch. If the return to "normal" fishing happens, it is unlikely that any benefit gained in the 2-year intervention period will have had noticeable effects on the vaquita's population levels. Similar is true for the Fisher's livelihoods. Current subsidies may buffer the effects of lost revenues in the short term, but there is no guarantee of continued government payments.

The environmental impacts of the switch to trawl gear have also been left unconsidered. For example, in El Golfo de Santa Clara, the 255 trips by 49 boats using both kinds of trawlers during the gear-testing period trawled an area of 2,819 km² that corresponds to 30% of the biosphere reserve's total area (Figure 2). Considering there are more than 600 boats with shrimp permits (Erisman *et al.* 2015), the volume of discarded bycatch and the potential negative effects of such activities on juvenile fishes, invertebrate communities, and bottom habitats are likely to be substantial enough to disrupt the integrity of the whole ecosystem (Lewison *et al.* 2004; Hinz *et al.* 2009). This deserves important consideration as the UGC is home to the breeding and nursery grounds of species listed as critically endangered (*Phocoena sinus* and *Totoaba macdonaldi*) and numerous other endemic species (e.g., *Cynoscion othonopterus*; *Scomberomorus concolor*) that are highly vulnerable and/or valuable to the local economies (Erisman *et al.* 2015). For example, bycatch of juvenile totoaba was identified a causal factor in the collapse of the fishery and the species (CisnerosMata *et al.* 1997). The recovery of the totoaba is already threatened by widespread poaching of adults, and the potential impacts of juvenile bycatch by this new trawl fishery has not been assessed. Likewise, large volumes of juvenile corvinas were reported in the first experimental tests of the new trawls (INAPESCA 2009).

A long history of investment in the fisheries with little consideration for local ecology has favored extraction over conservation in Mexico (Cisneros-Mata 2010). Our

estimations of the potential subsidy expenditure required for the use of the RSINP trawls instead of gillnets are conservative (\approx US \$8.5 million in subsidies per year; two third of the net revenue plus 30% of fuel consumption), because the gear switch will also bring changes in fisher training and increased industrialization of the fishing sector in terms of engine use and fuel efficiency (e.g., a move to diesel engines). These are all costs additional to the already planned US \$72 million for the emergency gillnet ban of 2015–2017 (Malkin 2015), which represents the earnings of the active fishers in the UGC over a 2-year period, as well as the costs of surveillance during the gillnet ban.

It is also noteworthy that the UGC fishing industry suffers from a monopsony market situation, in which all sellers interact with one or very few buyers, reducing the options for individual fishers to obtain higher market values or the option of value adding before sale (Valdez-Gardea 2007). The authors believe such a situation has evolved due to the UGC's remote location and lack of external investment and internal training of the fishing community. The monopsony could be addressed in a number of ways, including investment bringing new seafood purchase and/or packing companies to the area, and by training fishers to value add to their own catches. Without reducing or eliminating the monopsony, market-price strategies proposed for the region and within the vaquita agenda, will continue to fail or generate benefits to a limited number of stakeholders (Klein *et al.* 2015).

The holistic and long-term vision

To date, no long-term goals have been designed for the UGC and the few collaborative efforts between conservation and extractive sectors have had disappointing results. Conservation policies must consider the extractive sector (in this case fishers) as partners rather than opponents, to increase compliance and the probability of success (Reed 2008; Leslie *et al.* 2015). The vaquita conservation agenda should move toward restoring balance between the different groups involved, and immediate attention paid outside of fishery subsidies and high impact fishing gear switches is needed.

It is necessary for all groups involved to acknowledge that the root of the problem lies in the lack of support for communities that have been built on an extractive industry, which is detrimental to an endemic species. It is necessary to push for an urgent agreement between the conservation and fishery sectors to resolve fundamental community needs. These communities face serious needs for basic infrastructure in order to develop other kinds of economies beyond fishing (Avila-Forcada *et al.* 2012).

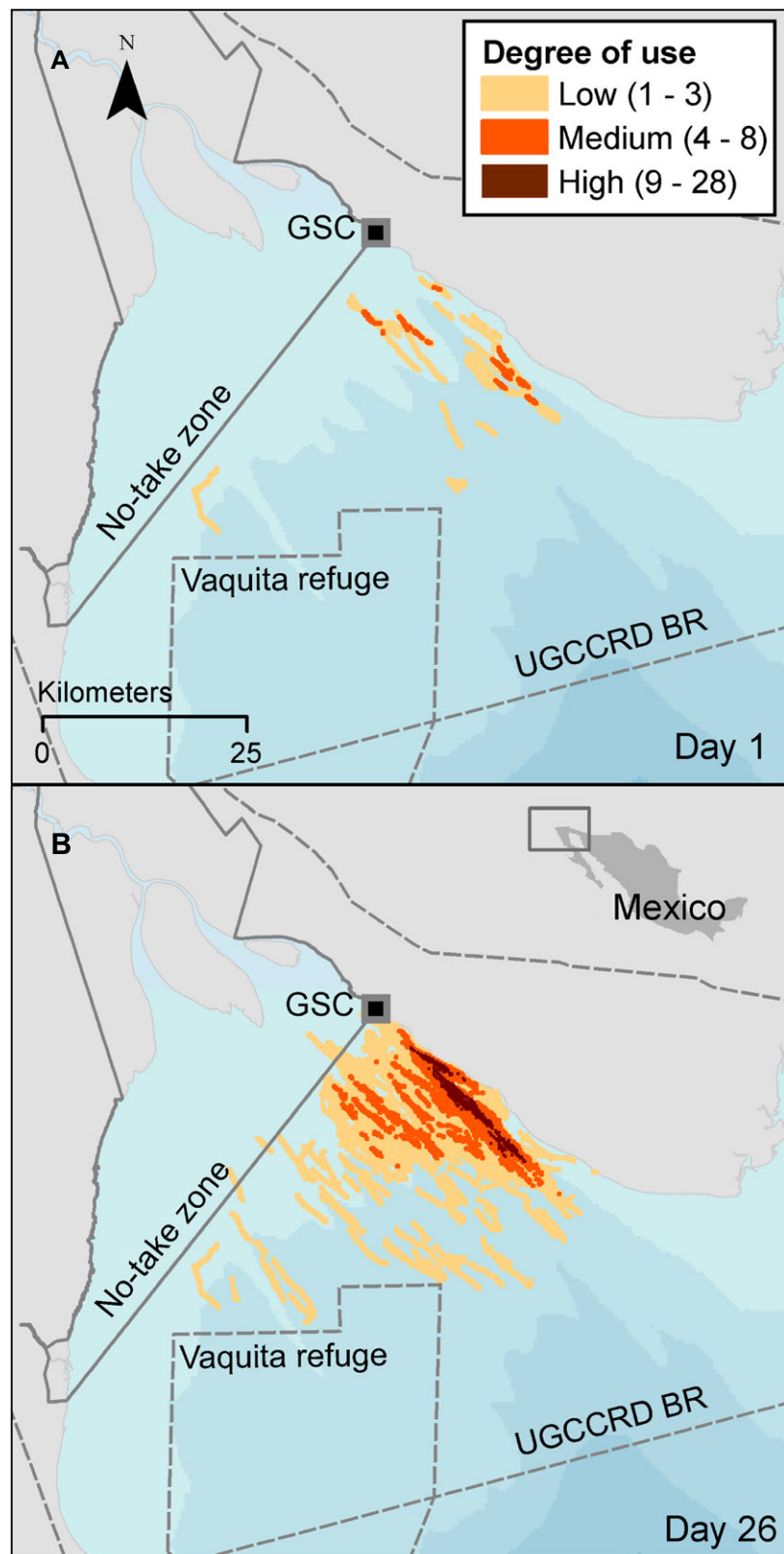


Figure 2 Map of the Upper Gulf of California demarcating the areas trawled by fishers during government gear testing in 2013. (A) shows the fished area during the first day of testing (137 km²) and (B) the total area fished after 26 days of testing (2,819 km²). UGCCRD BR, Upper Gulf of California and Colorado River Delta Biosphere Reserve; GSC, Golfo de Santa Clara. Legend denotes the degree of use (number of trawl passes).

With very few options for alternative livelihoods, fishing recruits men as young as middle school level, creating a cycle where the scenario of once a fisher, always a fisher occurs. Government investment in better education and training in the UGC would help increase livelihood options (Rodríguez-Quiroz & Aragón-Noriega 2013), such as sports fishing tourism or other service industry activities that would potentially help increase the environmental awareness and the promotion of longer-term visions in the region.

The last minute management decisions of fishery closures and altered fishing gear types in the UGC only addresses an immediate issue (bycatch of the vaquita) and therefore overall, fails two-fold. It disregards the long-term sustainable use of the wider ecosystem by not accounting for the negative impacts of using destructive trawl practices. It also neglects approaches that include local fishers and their knowledge that would likely consider longer-term, larger-scale sustainability of the UGC system. For example, because the establishment of the reserve, fishing effort (number of fishers and boats) has not decreased but remained stable; something fishers have agreed needs to be addressed, especially considering the unknown levels of illegal fishing. This, however, has not been a priority for the government nor the conservation sector, and has been left unaddressed. The best-case scenario is always one in which the extractive and conservation sectors involved collaborate toward a commonly shared goal (Goodrich *et al.* 2011; Barner *et al.* 2015; Finkbeiner & Basurto 2015). Reductions of fishing effort can be one of these goals and is an indicator easy to measure in the long term.

If social wellbeing is given priority, the authors believe that longer-term sustainable local fisheries are more likely to develop which, in turn will help develop marine stewardship in the fishers and the community (Cisneros-Montemayor & Vincent 2016). Curbing vicious cycles in which one resource is depleted after another should be a primary goal of fisheries managers in the UGC. Fishers need inclusion from the start in the design of new conservation initiatives. Solely informing a fisher of a new rule, even though it affects their livelihood, should not be expected to produce friendly relations. Previous inclusions in enforcement activities by the government relating to the vaquita refuge (Environmental Investigation Agency 2016) likely failed due to discontent that already arose from the exclusion of fishers early in the UGC's conservation history.

Initiatives that focus on biodiversity conservation and threatened species rely on top-down management approaches. Most of the time these approaches are incapable of engaging different sectors of society, especially in communities from developing countries (Rodríguez *et al.* 2007). Subsidies often help sustain extractive ac-

tivities, the result of which commonly opposes conservation agendas. This study highlights that the government-proposed gear switch for vaquita conservation, will likely necessitate more subsidies to maintain fishing livelihoods as they were before the gillnet ban. This will perpetuate over-capacity, fuel conflict between the conservation and fisheries sector and ultimately reduce the likelihood of conservation success, for what is already a mammal population on the brink of extinction. Ignoring the players in conservation-extraction scenarios, denying the existence of the tightly coupled social–economic–ecological relationships or ignoring opportunities to increase cooperation (Sawchuk *et al.* 2015), will perpetuate the design of unsuccessful, top-down management strategies, which often put the integrity of the ecosystems at further risk (Ban *et al.* 2013).

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

Figure S1: Classification of point data generated by a GPS data-logger using the speed to identify where the gear was potentially deployed and retrieve during a gear test for (a) gillnets and (b) trawlers.

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