An Analysis of Bioeconomic Tradeoffs in Vaquita Conservation Policies

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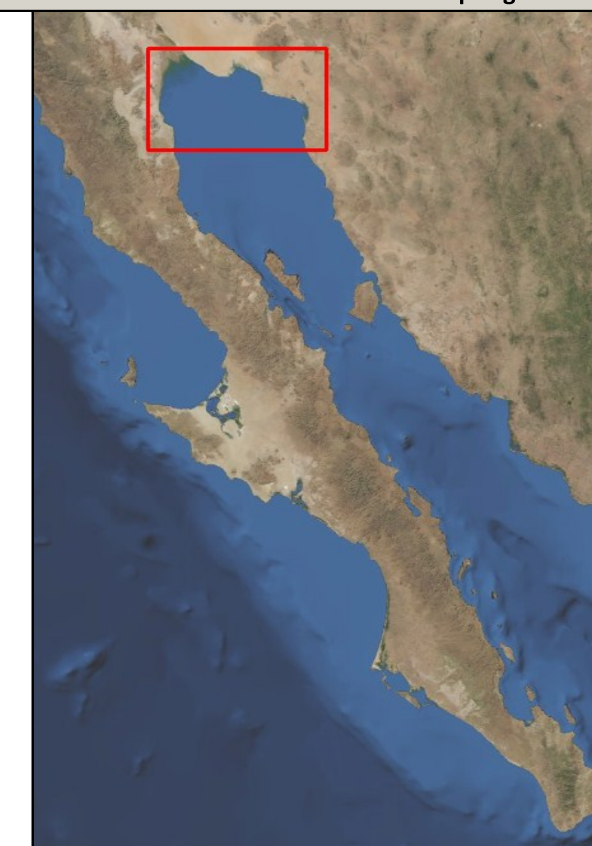
Introduction



Mexico's only endemic marine mammal, the vaquita (*Phocoena sinus*), is a porpoise widely cited as the most endangered mammal in the world. With an estimated population of fewer than 200 individuals remaining in the Upper Gulf of California, entanglement in shrimp and fish gillnets threatens the vaquita with extinction within the decade.

Since early conservation efforts began in 1993, the Federal Government of Mexico has invested over $30 million USD in an attempt to maintain fishing livelihoods while protecting the vaquita, yet current management strategies have failed to halt the continual population decline. Thus, there is an urgent need to heighten conservation efforts, but such efforts must be sensitive to economic impacts on the local human population.

The economies of two fishing communities in the Upper Gulf of California, San Felipe and Golfo de Santa Clara, are heavily dependent on artisanal gillnet fishing for shrimp and finfish. With few alternative livelihoods, any policy that heavily restricts fishing in order to reduce vaquita bycatch will negatively impact local economies.

Project Objectives

- Identify viable vaquita conservation policies in the Upper Gulf of California
- Model impacts of policy combinations on the vaquita population growth rate and the regional fishing industry
- Provide an evaluation of bioeconomic tradeoffs for a more explicit and transparent decision-making process

Recommendations

Increase refuge size: we recommend increasing the size of the Vaquita Refuge in order to encompass a larger percentage of the population. Our results show that larger refuges are central to any policy with the outcome of vaquita population growth.

Restrict all gillnet fisheries: Policy outcomes do exist with projected outcomes of marginal vaquita population growth from a closure of the gillnet finfish fishery. Outcomes with significant population increase only result from combined shrimp and finfish closures. Closing shrimp gillnetting alone is not projected to lead to vaquita population growth.

Increase compliance to a minimum of 80%: for any policy implemented, there should be priority in achieving higher levels of compliance. Our results indicate that when compliance for any policy combination is below 80%, vaquita population growth will not be achieved.

Implement artisanal trawl: the prototyped light trawl should be implemented to capture revenue forgone by gillnet closures. Our results indicate a bioeconomic optimum from closing a larger area to gillnetting, but allowing use of the zero-vaquita bycatch trawl where restrictions occur.

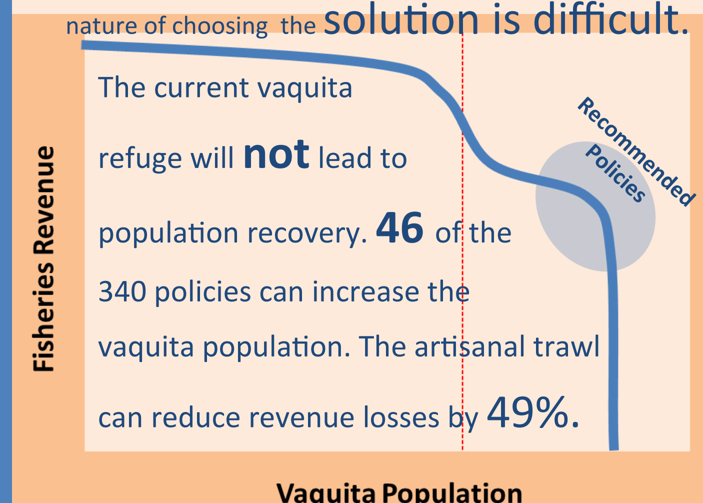
Additionally, we recommend further research into potential benefits to fisheries from spatial closures in order to enhance the economic assessment of policies. Research into other zero-vaquita bycatch alternative gears should also be prioritized (e.g. long-lines, fish traps, diving, cultivation). Such additional insight can be used to enhance the projections of this model.

Tradeoff Analysis as a Conservation Tool

The tradeoff analysis is a tool that provides a spectrum of policy outcomes that can be used by multiple stakeholders in decision making processes that may aim to improve vaquita conservation, fisheries revenue or both of theses interests.

A total of 46 policy combinations were identified that will achieve vaquita population growth at economic losses ranging from approximately 21-100% of current total fishery revenue. While our findings did not find a win-win scenario in vaquita conservation, they do provide a comparative evaluation that can optimize future management strategies.

While the nature of this **problem is simple**, given that the main threat to vaquita extinction is known, the nature of choosing the **solution is difficult.**



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1. Fishing effort data came from Marcia Moreno-Baez at Scripps Institute of Oceanography. Moreno-Baez, M. et al. (2012). *Ocean and Coastal Management*, *55*(C), 111–127.

2. Gerrodette, T. et al. (2011). *Marine Mammal Science*. 27(2): E79-E100.

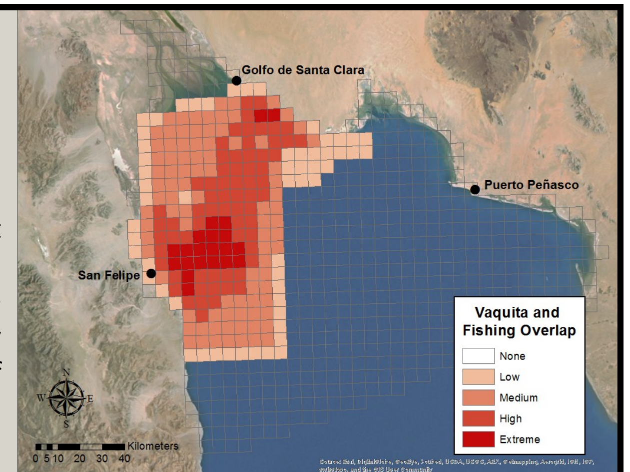
Approach

A spatially-explicit bioeconomic model was developed to evaluate a wide range of conservation policies within five vaquita refuge designs. Modeled policies were combinations of varied gillnet fisheries closures, levels of compliance within each refuge, reduction of fishing effort through a buyout program and the implementation of an artisanal shrimp trawl. Revenue effects were calculated as a function of the change in total landings per species resulting from each of these policy combinations. Incidental vaquita bycatch was calculated as a function of the final fishing effort under each policy, the catchability of the vaquita and its and spatial distribution in the Upper Gulf of California.

Spatial data on fishing effort[1] and vaquita density[2] were mapped to represent the interactions between fishers and the vaquita population. In the figure to the right, areas of darker red indicate instances of highest interaction between fishers and the vaquita.

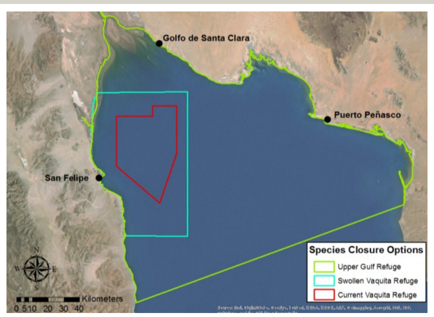
Under each policy, fisheries revenue was calculated as total profits less fishing costs. Both cost and fish value data came from CONAPESCA (National Fisheries Commission).

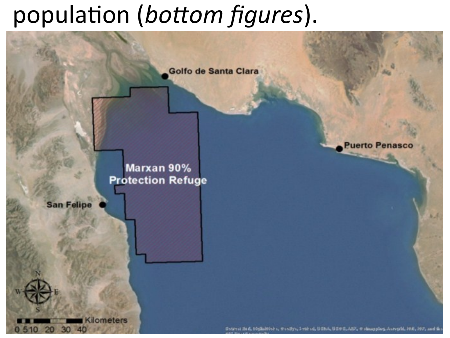
The vaquita population growth rate was calculated by modeling the number of individuals caught as bycatch under each policy, then using this number to estimate population growth or decline.

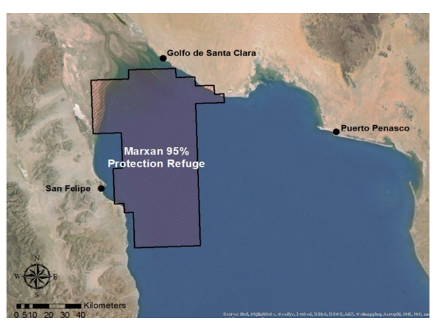


Spatial Refuge Options

Our model considered five separate vaquita refuge designs including the current refuge and two recently proposed expansions (*right figure*) and two designs derived by conservation planning software, Marxan, that protected 90% and 95% of the vaquita population (*bottom figures*).







Modeled Policies

Recent vaquita conservation policies in the Upper Gulf of California include the current vaquita refuge, created in 2005, a gear switch-out and a gear buy-out program. These strategies have minimally reduced fishing effort and are expanded upon in our model through the inclusion of the following policies:

1) **Spatial Closures:** Five possible vaquita refuge designs were represented in our analysis including the current refuge.
2) **Fisheries Closures:** We evaluated the impacts of closing the shrimp gillnet fishery, the finfish fishery, both fisheries together and the impact of no fishery ban.
3) **Gear Buyout Program:** Four different levels of a buyout program were included in our quantitative model as a total reduction in effort ranging from 0% to 30%.
4) **Compliance:** Our model accounted for varying levels of fisher compliance for each vaquita refuge, ranging from 40-100%.
5) **Alternative Trawl:** A recently proposed artisanal shrimp trawl was evaluated as an alternative to gillnets.

Spatial Closures
- Current Refuge
- Swollen Refuge
- Marxan 90%
- Marxan 95%
- Full Closure of the UGC

Species Closures
- No Fishing
- Finfish Only
- Shrimp Only
- All Fishing Open

*Alternative Trawl

Levels of Buyout
- 0%
- 10%
- 20%
- 30%

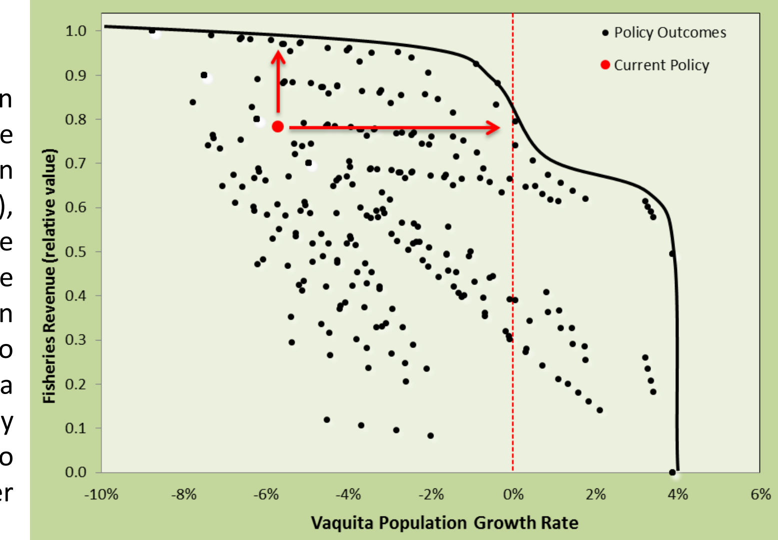
Levels of Compliance
- 40%
- 60%
- 80%
- 100%

=

340 Policy Combinations

Tradeoffs in Conservation Policies

Out of the 340 policies modeled, 46 resulted in an increasing vaquita population growth rate and lie to the right of the red line. The outer bound of outcomes, known as the ***efficiency frontier*** (black line in figure at right), identifies policies that perform best for fisheries revenue and vaquita population growth. The model found that the current scenario, highlighted by the red dot, is not an efficient policy and can undergo pareto improvements to increase both regional fisheries revenue and the vaquita population growth rate. The downward sloping efficiency frontier indicates a clear tradeoff between the two interests; vaquita population growth is only possible under policy scenarios that reduce fisheries revenue.



Fisheries Revenue is represented as a proportion of the maximum possible revenue, which is set to equal 1. Vaquita population growth rate was calculated using the exponential growth model.

Policy Outcomes

An in depth look at the tradeoff plot highlights some important impacts of each policy on fisheries revenue and vaquita population growth rate. Policies that keep the current vaquita refuge (top left), have less than 80% compliance (top right) and/or close just one gillnet fishery (bottom left) will have very little chance of increasing the vaquita population. The most impactful policy is the implementation of the artisanal trawl (bottom right) which will have no impact on the vaquita but has the potential to greatly reduce impacts to fisheries revenue.