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 fishing gillnets threatens the vaquita with extinction within the decade.

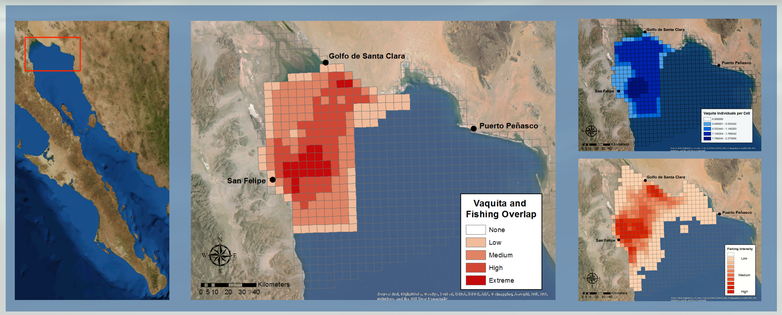
Since early conservation efforts began in 1993, the Federal Government of Mexico has invested over $30 million USD in conservation initiatives for the vaquita, but the decline in population has continued.

The economies of San Felipe and El 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 vaquita population and the regional fishing industry
- Provide an evaluation of bioeconomic tradeoffs for a more explicit and transparent decision-making process

Spatial Overlap of Vaquita and Artisanal Gillnet Fishers



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

Calculating Fisheries Revenue and Vaquita Population Growth

The number of vaquita caught as bycatch under each policy was calculated based upon the total vaquita abundance, a catchability parameter, amount of fishing effort and total number of fishing boats on the water. Total bycatch was translated into a bycatch rate and used in the exponential growth equation to determine the population growth rate for each of the 340 policies.

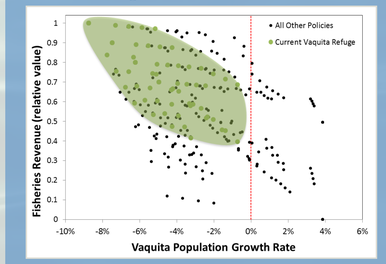
Number of Vaquita caught as bycatch (B) = Vaquita Abundance X Catchability Parameter X Estimated Fishing Effort X Number of Fishing Boats

Fisheries revenue was calculated as total profits from landings for all species, less the cost of fishing. Landings and fish value data came from Mexico's National Fishing Commission (CONAPESCA).

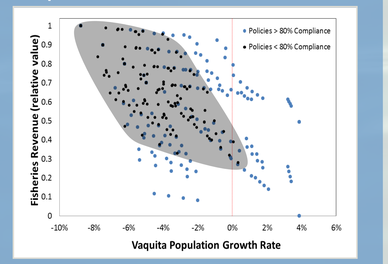
Fisheries Revenue = Landings X Price − Costs

Interpreting Results

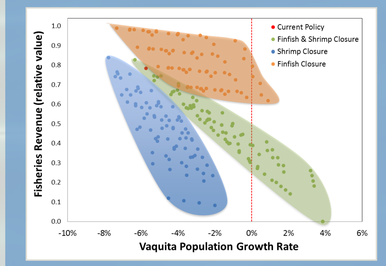
Current Refuge



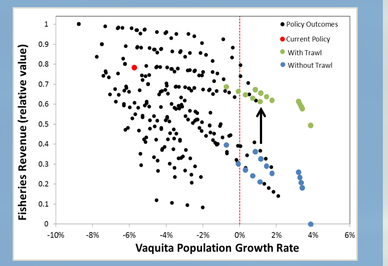
Compliance



Fisheries Closures



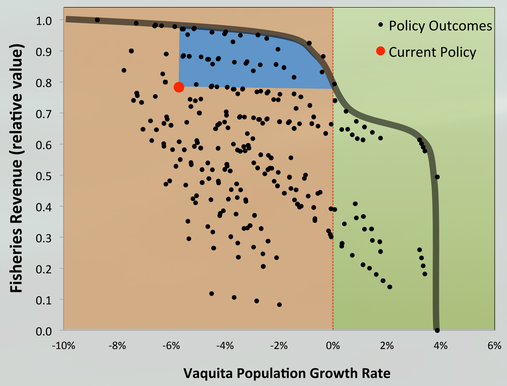
Implementing the Artisanal Shrimp Trawl



An in depth look at the tradeoff plot highlights some important effects each policy has on fisheries revenue and the vaquita population growth rate. There is very little chance of increasing the vaquita population if a policy incorporates the current vaquita refuge, has less than 80% compliance and/or closes just one gillnet fishery. Implementation of the artisanal shrimp trawl minimizes expected losses to fisheries revenue without decreasing the vaquita population growth rate.

Projected Policy Outcomes

Out of the 340 policies modeled, 46 resulted in vaquita population growth. The outer bound of outcomes, known as the *efficiency frontier*, identifies policies that perform best for fisheries revenue and vaquita population growth. Policies that fall to the right of the red line are predicted to have vaquita population growth. As modeled, the current policy does not prevent further population decline.



Points highlighted in blue represent policies that increase both objectives compared to the current policy

Points highlighted in green represent policies that lead to an increasing vaquita population size

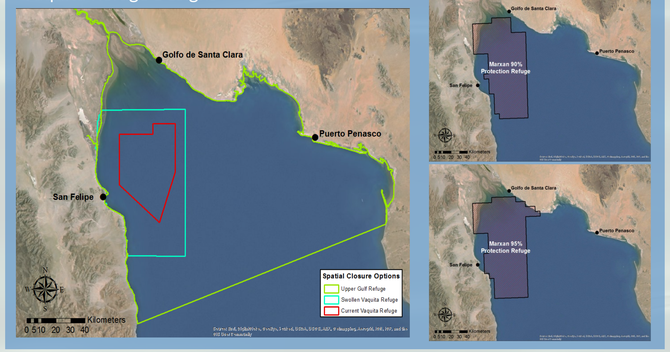
Points highlighted in orange represent policies that lead to a decreasing vaquita population size

The black line, known as the efficiency frontier, highlights those policies that perform best for fisheries revenue and vaquita population growth

Policy Options Evaluated

The bioeconomic model evaluated a wide range of policies within five 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).

Vaquita Refuge Designs



Modeled policies were combinations of fisheries closures, levels of compliance within refuges, fishing effort buyout and the use of an artisanal shrimp trawl.

Spatial Closures	Species Closures	Levels of Buyout	Levels of Compliance	
• Current Refuge • Swollen Refuge • Marxan 90% • Marxan 95% • Full Closure of the UGC	• No Fishing • Finfish Only • Shrimp Only • All Fishing Open *Artisanal Trawl	• 0% • 10% • 20% • 30%	• 40% • 60% • 80% • 100%	= 340 Policy Combinations

Artisanal Shrimp Trawl Implementation of an artisanal shrimp trawl to catch blue shrimp that has been proven to have zero impact on vaquita. Only applied to policies with 100% compliance and full fisheries closures (20 additional policies).

Recommendations

- **Increase refuge size** since the vaquita population will continue to decline with the current refuge
- **Restrict all gillnet fisheries** as significant population increases only result from combined finfish and shrimp closures.
- **Increase compliance to at least 80%** as lower compliance levels cannot support vaquita population growth.
- **Implement artisanal shrimp trawl** to recover revenue forgone by gillnet closures.

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2. Gerrodette, T. et al. (2011). *Marine Mammal Science*. 27(2): E79-E100.
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Vaquita Image: Cristian Faezi and Omar Vida (retrieved from iucn.org)

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