The Restoration of Catarina Scallop (*Argopecten ventricosus*) in the Ensenada de La Paz

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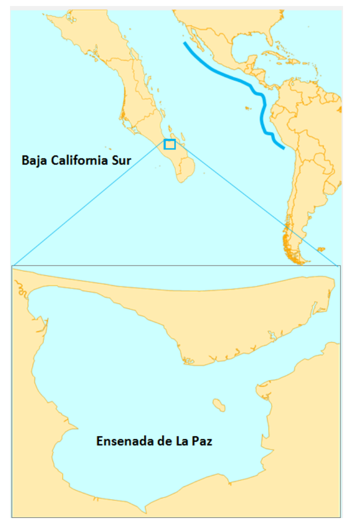
For project updates please visit: http://www2.bren.ucsb.edu/~catarina/ **Spring 2014**

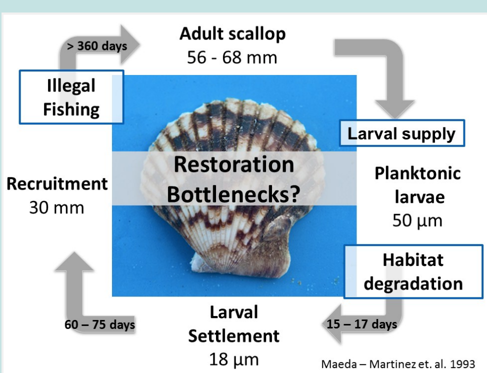
Overview

The recovery of the Catarina scallop *Argopecten ventricosus* in the Ensenada de La Paz has important implications for the coastal lagoon ecosystem and also the El Manglito fishing community who depended on the scallop for generations. The Catarina population collapsed in the late 1970s and has not recovered naturally in the Ensenada de La Paz. Since then, the Catarina fishery and the socioeconomic benefits derived from the fishery disappeared as the community observed the deterioration of the Ensenada ecosystem; resulting in the local fishermen migrating to other areas to fish. Beginning in 2012 the fishermen and their families formed alliances with Noroeste Sustentable (NOS), and started an aquaculture project to repopulate the Ensenada with Catarina scallops. Our project was designed to address the questions (1) what processes and constraints limit the recovery of Catarina scallops and (2) what interventions and restoration activities are needed to overcome those constraints.



Ecological Bottlenecks

We investigated the life cycle of the Catarina scallop in order to identify restoration bottlenecks that may inhibit the scallop recovery and mechanisms that may enhance it.



Possible factors and processes limiting natural recovery

Lack of scallop habitat may limit the substrate for Catarina recruits to settle.
Illegal fishing can reduce the seeded scallop number.
Population isolation from others may merit further seeding.
Restoration may be accelerated by increasing the length and quantity of scallops seeded into the wild.
Aquaculture could generate an income source for the fishermen and fund the recovery gap, while the Catarina population recovers and wild fishery opens.

Project Objectives

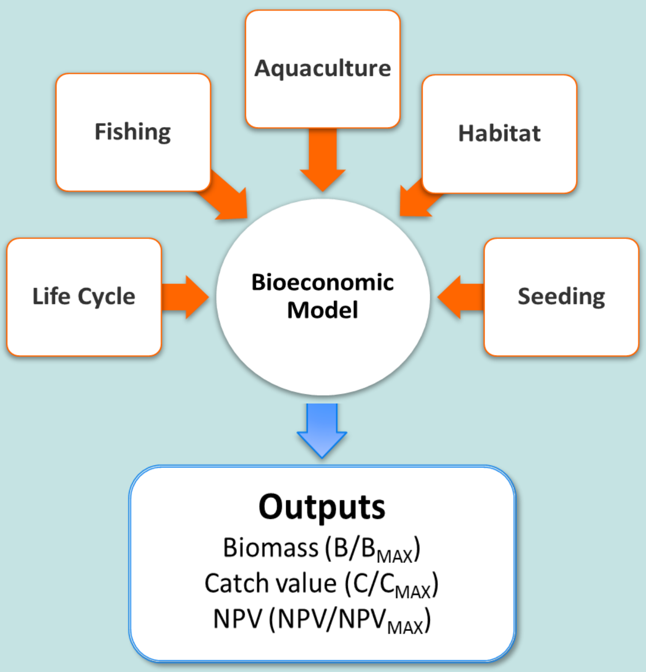
Develop and evaluate alternative restoration strategies and provide recommendations that:

- Optimize the recovery of the Catarina scallop population
- Maximize economic benefits to the local community from the expected recovery

Approach

To explore alternative restoration strategies and thus attain our objectives we created a bioeconomic model to simulate conditions and various management scenarios designed to increase the scallop population in a cost-effective manner. We used life-cycle parameters and relationships to develop an age-structured population model. This model builds upon the Von Bertalanffy growth function, the Beverton-Holt stock-recruitment relationship, length-weight relationship, fecundity, maturity, natural mortality, fishing mortality, and illegal fishing mortality. Each time interval represents 1 year, and the population was simulated through 100 years. We tested 15 scenarios, each a unique combination of habitat restoration, aquaculture intensity, illegal fishing and seeding.

Bioeconomic Model Inputs and Outputs



Restoration Parameters

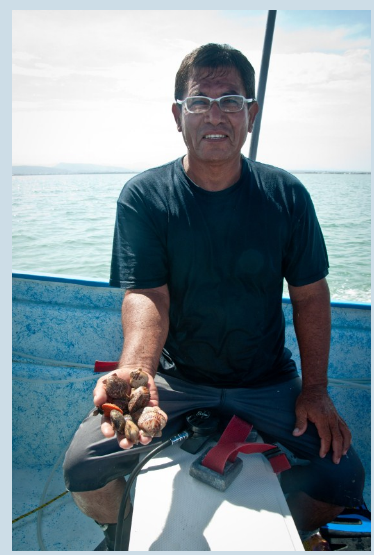
Variable	Ranges		
Habitat Restoration	30%	60%	100%
Illegal Fishing Pressure	5%	20%	40%
Aquaculture	0	580,000	2,320,000
Seeding period (years)	1 year	3 years	6 years
Seeding quantity	340,000	680,000	n/a

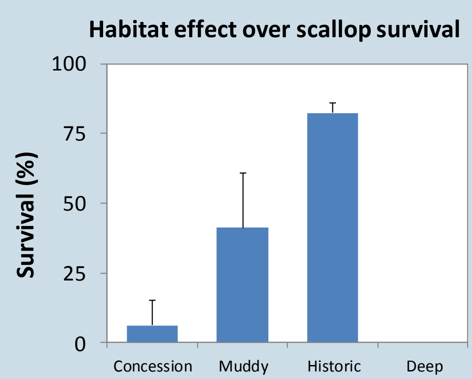
Model Assumptions

- Illegal fishing is controlled relatively well by the level and effectiveness of surveillance.
- We used recruitment as a proxy for habitat availability by assuming recruitment is limited by the level of Catarina suitable habitat.
- The estimated scallop abundance during the final year the fishery was open was used as a reference for historical abundance.
- The present available habitat is 30% of the habitat available in the final year the fishery was open.
- The scallops in aquaculture would be grown out in cages to the legal size and then harvested for sale.

Catarina Survivorship Experiment

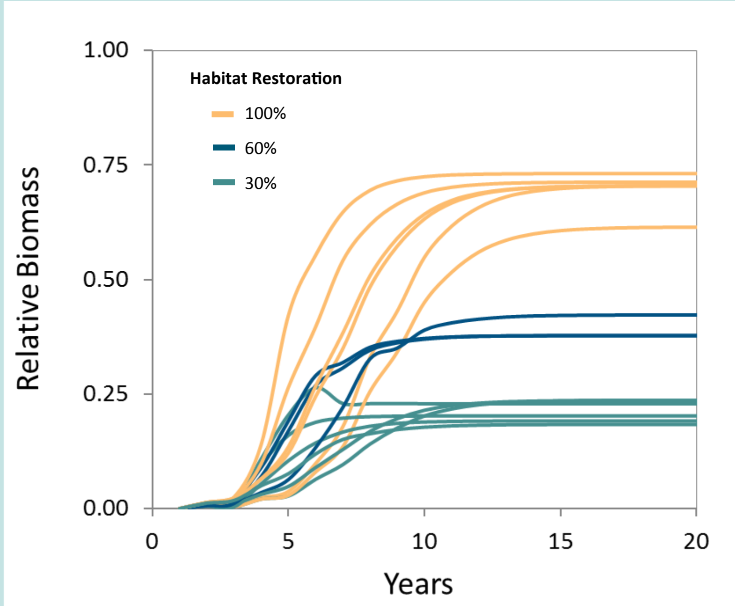
We performed a field experiment conducted in July 2013 to test whether survival of scallops varied as a function of different habitat types available in the Ensenada: a concession site, a muddy site, a deep site and a historic site. The concession site is a government granted area for fishers to carry out experimental aquaculture; it has some shell hash and algae. The muddy site mainly has fine sediment and very low visibility. The deep site has sandy channels with some mud, shell hash and algae. Our results show that the highest survival rate occurs in the historical fishing grounds where the substrate is dominated mainly by shell hash and algae.





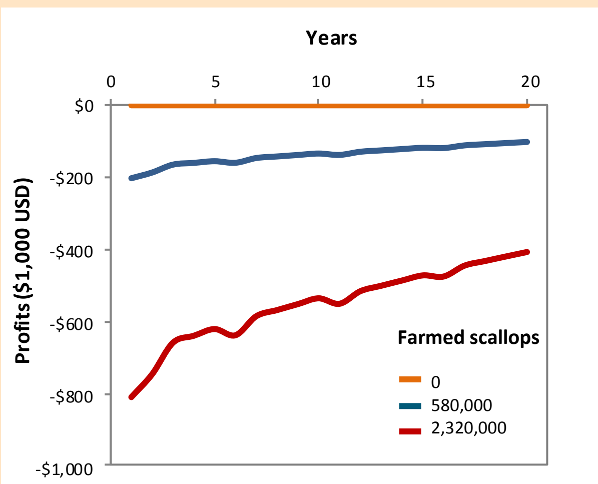
Evaluation of restoration strategies

The results of the bioeconomic model indicated that the highest scallop biomass would be reached by only 6 of fifteen scenarios. These 6 scenarios all assumed that scallop habitat was restored to 100%. Lower biomass strategies assumed levels of 30% or 60% of suitable habitat. In our model, the wild scallop fishery would open after the population arrived at 25% of theoretical virgin conditions. Our results showed that the fishery opened in 10 of 15 scenarios and in all but one scenario the population size remained above the 25% threshold. All 5 scenarios that never reached a population size above the 25% threshold assumed low levels of suitable habitat. Scenarios that attain a higher biomass while the fishery was closed maintained a larger population once the fishery opened. How soon the fishery opened affected how the population recovered. However, in all cases the population stabilized after 20 years assuming a legal fishing rate of 60%.

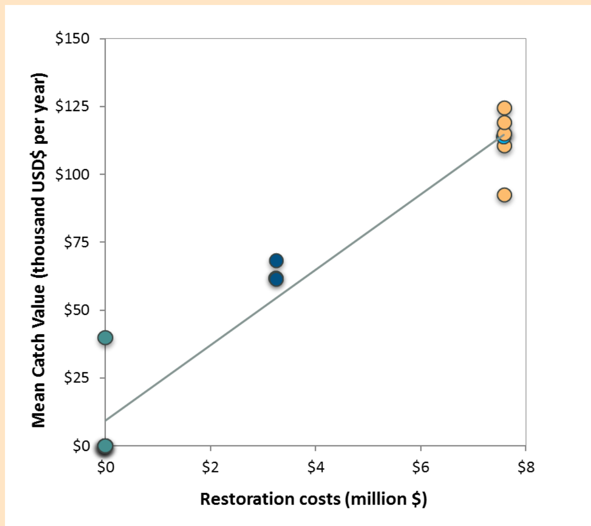


Growth of scallop population (biomass) over time for 15 restoration strategies. Colors indicate levels of habitat restoration (green=30%, blue= 60%, orange=100%). Variation within habitat levels is caused by levels of illegal fishing or seeding intensity.

Economic Feasibility



Present value of the Aquaculture operation using a 3% discount rate and over a 20 year period. Scenarios with higher aquaculture intensity had the most negative net present value.

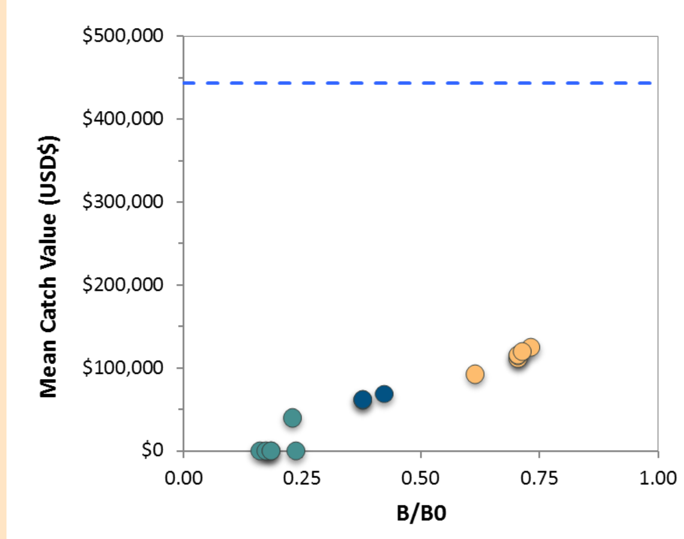


Mean catch value per year in reference to the amount invested in habitat restoration in millions of dollars. Colors indicate levels of habitat restoration (green=30%, blue= 60%, orange=100%).

We calculated the Net Present Value (NPV) of the wild fishery and aquaculture in order to determine the worth of each parameter over time. The scenarios with the highest fishery income NPV have high restoration investments due to the costs of restoring habitat to 60% or 100%. Our results show a relationship between mean catch value and habitat restoration investment. The corresponding NPVs at a 3% discount rate for 100 years were negative or zero. In order for aquaculture to break even under the current cost and at the current market price, approximately 4 million scallops may need to be produced. This quantity may be achieved by doubling the density per cage from 200 to 400 scallops/m^2, or the percentage of aquaculture area occupied by cages from 10% to 20%.

Discussion

The maximum value attainable by the scallop fishery per year would be less than half of the revenue amount needed to sustain the livelihood of the El Manglito fishermen. Although the Catarina fishery could generate profits, it alone is not currently sufficient to support these fishermen. This analysis, however, assumed that the biomass was limited to that in 1978, one year before the collapse of the Catarina fishery in the Ensenada. The scenarios with negative NPVs were also limited by the assumption that the fishery would open when the biomass reached 25% of the 1978 level. The Catarina fishery has the potential to become economically feasible, especially if habitat is restored and surveillance and seeding efforts continue. Combined with other recovering local fisheries like Pen Shell scallop, the Catarina fishery may be able to satisfy the income needs of the El Manglito fishers.



Mean catch value per year in relation to biomass of the wild population. The dashed line represents an estimate of the amount required to sustain the livelihood of the El Manglito fishermen. Colors indicate levels of habitat restoration (green=30%, blue= 60%, orange=100%).

Recommendations

Restore scallop habitat in the historical fishing grounds, and conduct further research to assess the best strategy to restore the habitat.

Continue seeding effort and for at least 3 years and if possible increase the quantity seeded up to 680,000 scallops per year.

Reduce poaching through community surveillance programs in the Ensenada.

Partner with private funders to support habitat restoration, as well as with research institutions such as the Bren School, the Massachusetts Institute of Technology to evaluate habitat restoration strategies.

Focus on the recovery of other fishing resources to meet the economic target set for the local fishing community, given that the scallop fishery alone would be unable to provide income for all the El Manglito fishermen.

Acknowledgements

We would like to thank Dr. Jono Wilson for his dedication to building a thorough bioeconomic model, for his availability to advise us through tough times, and for his guidance throughout our entire project. Dr. Hunter Lenihan for challenging us to think scientifically and for motivating us to broaden the way we think about environmental problems. The Fishermen of El Manglito, especially Hubbert & Guillermo Mendez, for taking the time to perform fieldwork during harsh conditions, teaching us to understand the prospective of the fishermen, and for verifying all the facts we find in the literature. Silvia Ramirez Luna for guiding us through our investigation, providing an avenue to developing a relationship with the El Manglito fishing community, and for her passion and dedication to this restoration project. Marisol Plascencia for helping us find funding to fulfill our goals. Liliana Gutierrez and Alejandro Robles for their passion for sustainable fishing communities, and for making this project possible.