Restoration of Catarina Scallop in the Ensenada de La Paz

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Background

The Catarina scallop, *Argopecten ventricosus*, is a species with high cultural and commercial value in Baja California Sur, Mexico (**Figure 1**). Although historically abundant in the Ensenada de La Paz, this fishery collapsed in the 1970s due to over fishing and natural disasters and has not yet recovered.

The restoration of the Catarina scallop fishery could:

- *Restore this native species to its historical range*
- *Increase stewardship of this and other fished species*
- *Contribute to fishers livelihoods*

The Ensenada Restoration

Noroeste Sustentable (NOS) is an NGO working with the local El Manglito fishing community to restore and repopulate the lagoon with Catarina scallops to levels high enough to reopen the fishery.

Together they have developed a small-scale nursery, growing scallops to be seeded into the wild. The goal is to seed enough mature scallops to rebuild the Catarina scallop population in the Ensenada to sustainable levels.

Figure 1. (A) *A. ventricosus* distribution, (B) Ensenada de La Paz study area in the Sea of Cortez in Baja California Sur, Mexico.

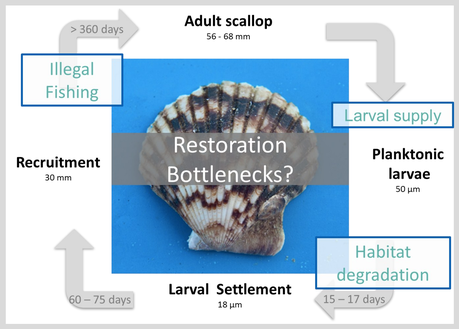

Figure 2. Life cycle of *Argopecten ventricosus* including the bottlenecks shown in the that could impede recovery. This process identifies the key factors to evaluate in our analysis.

Objectives

Develop and evaluate alternative restoration strategies and provide recommendations strategies that:

- *Optimize the recovery of the Catarina scallop population*
- *Maximize economic benefits to the local community.*

Methodology

1 Survival on different habitats

We performed a field experiment to test growth and survival of *A. vetricosus* on the main habitat types within the Ensenada coastal lagoon. Scallops were placed (N=40 per site) on 4 habitat types in bottom-free cages for 40 days.

2 Bioeconomic analysis

We created a model to simulate the socio-ecological relationships in *A. ventricosus* restoration (**Figure 3**). The model outputs indicate population size (measured by total biomass) and economic performance (catch value, NPV), projected 100 years after restoration begins.

We compared biological and economic results to determine the most beneficial restoration strategies based on our client's objectives.

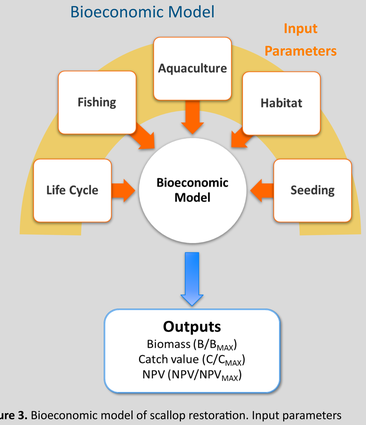

Figure 3. Bioeconomic model of scallop restoration. Input parameters were varied in the model to assess relative benefits of each restoration strategy.

Results and Discussion

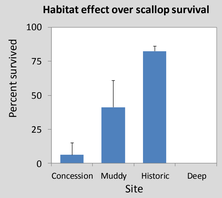

Figure 4. Survival of *A. ventricosus* after 6 weeks in one of 4 experimental sites. Scallops were placed in bottom-free cages exposed to natural environmental conditions.

Bioeconomic analysis

Population recovery

Available **habitat** for scallops is the most important factor in restoring the scallop population across the different strategies (**Figures 6, 7**). Strategies with low suitable habitat (30% of historical levels) biomass never reach a level at which the fishery can be opened. Providing shell as bottom substrata or restoring seagrass beds can promote the recovery of over-exploited or depleted populations.

Within each level of habitat availability other key factors affect levels and rates of recovery:

High **illegal fishing** has a negative effect on the rate of recovery and reduces the stabilized biomass of the Catarina scallop.

Seeding of scallop juveniles (340,000+ scallops/year) for at least 3 years optimizes recovery.

Aquaculture accelerates recovery by increasing larval supply but does not have a significant impact in the stabilized population level.

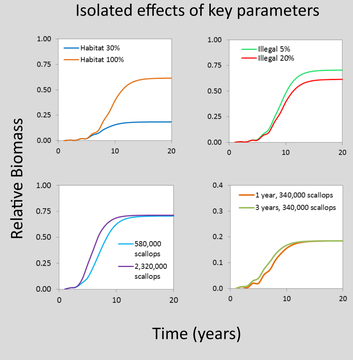

Figure 7. Mean catch value per year in reference to the amount invested in habitat restoration in millions of dollars for each scenario (*N*=15). Here we assume an average price of US$0.63 per kilogram of scallops with shell.

Survival on different habitats

Scallops can survive and grow on various types of habitat and substrate in the Ensenada.

Higher survival and growth rates were associated with habitats composed of shell, seagrass and/or algal turf cover.

Figure 5. Fisher Guillermo Mendez displays scallops from the survivorship experiment.

Biomass of recovered populations

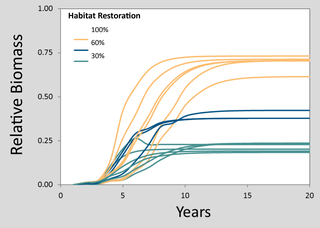

Figure 6. Growth of scallop population (biomass) over time for 15 restoration strategies. Variation within habitat levels is caused by levels of illegal fishing, seeding or aquaculture intensity.

Economic impacts

Fishery profits are highly dependent on the habitat restoration to 100% of the historical level, the market price for Catarina, and restoration investment.

The greater the **investment** made into habitat restoration, the higher the mean **catch value**.

When **price** is varied, the revenues from scallop sales can be almost 4 times greater when the price is high ($0.90/kg), compared to a low end price ($0.30/kg).

Aquaculture would not be profitable because of high labor costs and a low local scallop market price. Improvements in technology, reductions in labor costs and access to better markets are required to make a profit.

Restoration investment related to catch value

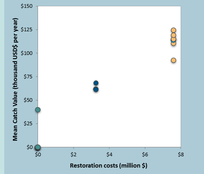

Figure 8. Relationship between the investment for habitat restoration and the mean value of annual catch per year for each of the 15 scenarios tested. Habitat restoration is represented by (orange=100%, blue= 60%, green=30%).

Model Assumptions

Habitat: Current habitat availability is at 30% of historical levels, habitat limits scallop recruitment, and maximum biomass is equal to that in the final year before the population collapsed (B_{MAX}).

Price: Price per scallop is fixed at US$0.63, which in reality will vary in time and depending on the market. If the market value of the scallop becomes too low, there will be less incentive to restore the Catarina habitat.

Fishery: The fishery will open when biomass reaches 25% of virgin biomass. The actual threshold is determined by the Mexican government agency CRIP, and depends on many factors.

Single focus: Many other commercially valuable species are found in the Ensenada such as the Pen Shell scallop, which would help to reach the economic target set by NOS (**Figure 9**).

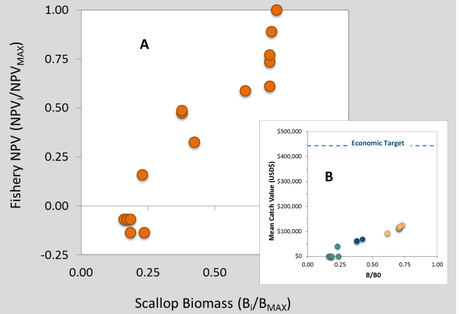

Figure 9. Tradeoff between the relative value of the fishery and its relative population size after 20 years. Each point represents a specific restoration strategy. In (A) the conservation axes is the relative biomass of the scallop population and in the economic axes is the relative NPV of the fishery. (B) shows the tradeoff between relative biomass and mean annual value of the catch, highlighting the minimum value needed to support the El Manglito community. Colors indicate levels of habitat restoration (orange=100%, blue = 60%, green=30%). Variation within habitat levels is caused by levels of illegal fishing or seeding intensity. The maximum value generated by the Catarina fishery can support only a portion of income needed by all the local fishermen (N=80).

Figure 10. Selection process of aquaculture juvenile scallops at the nursery. The nursery and aquaculture are run by fishermen of the local community.

Recommendations

- **Restore scallop habitat** in the historical fishing grounds and conduct further research to determine the best habitat restoration strategy.
- **Continue the community surveillance** program indefinitely, and **seeding effort** for at least 3 years and increase the quantity seeded up to 680,000 scallops per year.
- **Partner with private funders** to support habitat restoration, as well as with **research institutions** such as the Bren School, the Massachusetts Institute of Technology, or the Universidad Autónoma de Baja California Sur for further research.
- **Focus on the recovery of other fishing resources** to meet the economic target set for the local fishing community, given that the *A. ventricosus* fishery alone would only be able to provide income for less than half of the local fishermen.

Conclusions

- Habitat should be restored to 100% of its historical level for the population to recover to the highest biomass and to maximize benefits to the local fishing community.
- The Catarina fishery, under current cost and market conditions, has the potential to generate only 25% of the amount needed to sustain the livelihood of the El Manglito fishermen.
- Recovery of other commercially valuable bivalve species in the Ensenada should be considered to supply the remaining 75%.
- The Catarina fishery has the potential to once again be economically important, especially if restored simultaneously with the Pen Shell scallop and other historically valuable species in the Ensenada de La Paz.

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