Implications of Spatial Management of TURFs and MPAs for Interconnected Marine Systems

The case of Chaihuín in Valdivia, Chile

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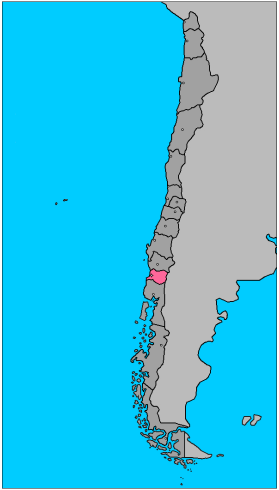
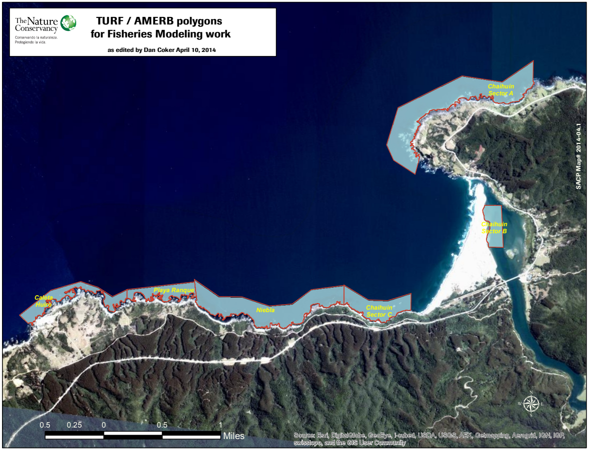
Background

- In 2003, The Nature Conservancy (TNC) created the "*Reserva Costera Valdiviana*", a rain forest reserve in southern Chile
- TNC established an agreement with 2 unions of fishermen next to the reserve
- Each of these unions owns three TURFs operated independently
- In 2009 each union agreed not to fish in one of their TURFs



Source: http://www.luventicus.org

Location: Chaihuín and Huiro



Source: The Nature Conservancy

Research Question

Is TNC's the right strategy?

Model framework

- Model able to reflect the stock's dynamics and movement through space
- Include strategic interaction between TURFs
- Include government influence and diversity of individual TURF management

Assumptions

- We considered the inter-connected system of patches
- Defined three possible management regimes:
  1. Open Access
  2. Marine Protected Area (MPA)
  3. Territorial User Right Fishery (TURF)
- Analyzed two type of interactions between TURFs:
  1. Coompetitive
  2. Cooperative
- Expanded the analysis for different movement ranges

Stock Dynamics

For patch i at time t:

Residual stock

$$X_{i,t} = S_{i,t} - H_{i,t} \tag{1}$$

Growth

$$G_{i,t}(X_{i,t}) = X_{i,t} + r_{i,t}X_{i,t}(1 - X_{i,t}/K_{i,t}) \tag{2}$$

Movement

$$S_{i,t+1} = \sum_{j} \mathbf{D}_{j,i} G(X_{j,t}) \tag{3}$$

Economic indicaotrs

For patch i at time t:

Profit

$$\Pi_{i,t} = pH_{i,t} - \int_{X_{i,t}}^{S_{i,t}} \frac{\theta}{B}\, dB \tag{4}$$

Net present value

$$J_i = \sum_{t=0}^{T} \beta^t \left(\Pi_{i,t}\right) \tag{5}$$

Decision variable (Fishing mortality F)

$$H_{i,t} = S_{i,t} F_i \tag{6}$$

Spatial definitions

Open access:

$$F_{i,t} = \frac{pS_{i,t} - \theta}{pS_{i,t}} \tag{7}$$

Harvest rule for MPAs and TURFs:

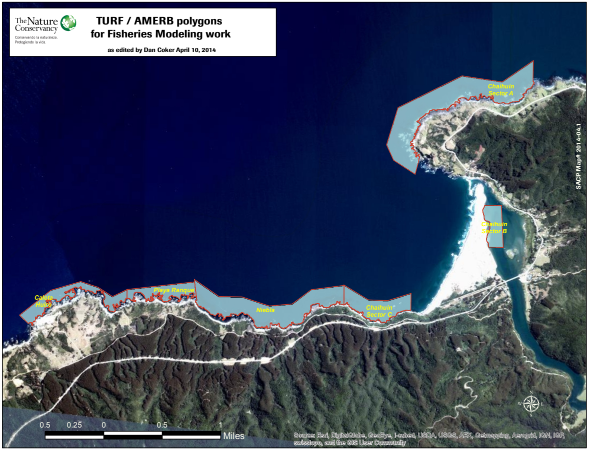
$$F_i \Rightarrow \begin{cases} \max\limits_{F_i(F_j^*)\ \forall j \neq i} (J_i) & \textit{Coompetitive} \\ \\ \max\limits_{F_i\ \forall i} \sum\limits_i (J_i) & \textit{Cooperative} \end{cases} \tag{8}$$

Scenarios to Evaluate

We evaluated all possible spatial combinations of the current system; however, we will focus only in four:

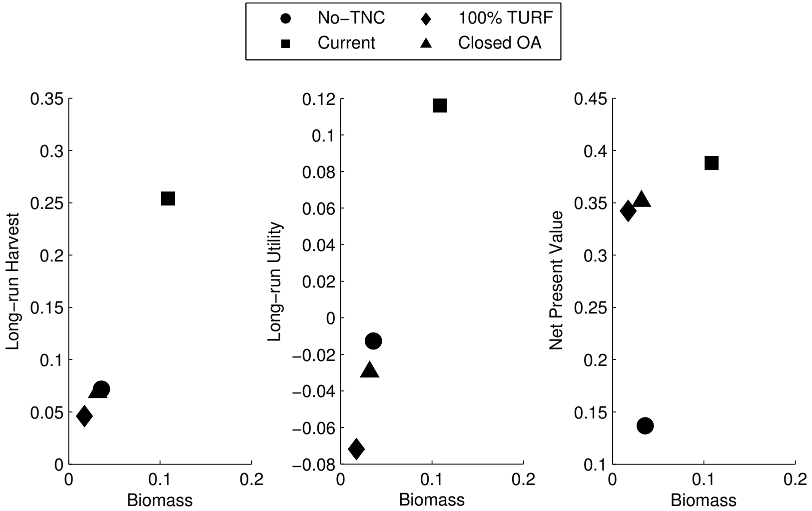
- No intervention from TNC (No-TNC)
- Current spatial arrangement (Current)
- Total privatization of the system (100%TURF)
- Closing of the open access (Closed OA)

Scenarios to evaluate



Source: The Nature Conservancy

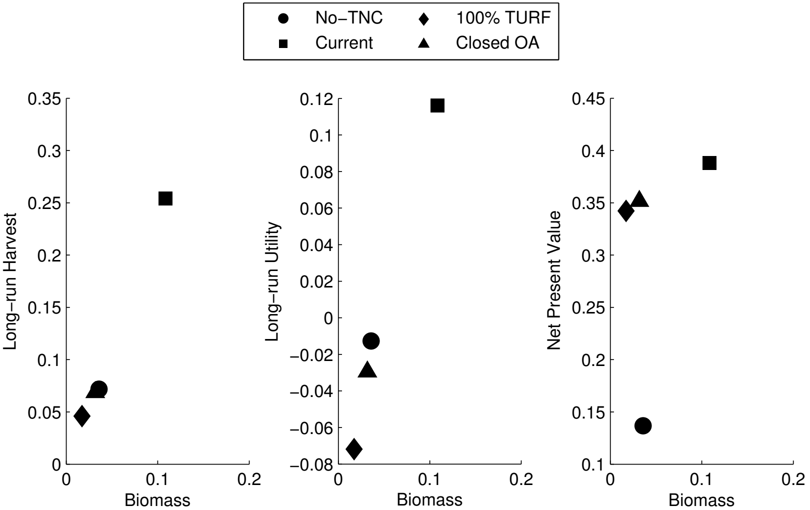
Competitive Scenario



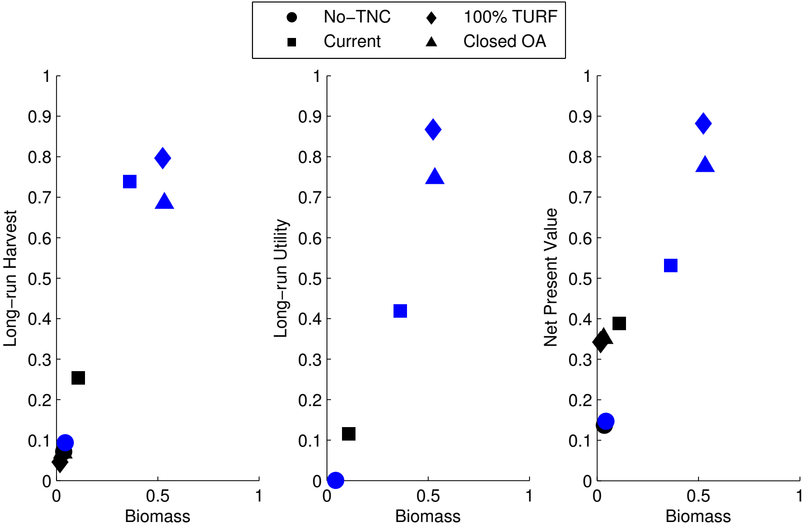
Competitive Scenario

- Competition between agents leads to efficiency problems
- The resource stock is what supports the competition
- TNC's intervention has a better performance than the other three
- MPAs could be justified when there is competition between agents

Competition



Cooperation



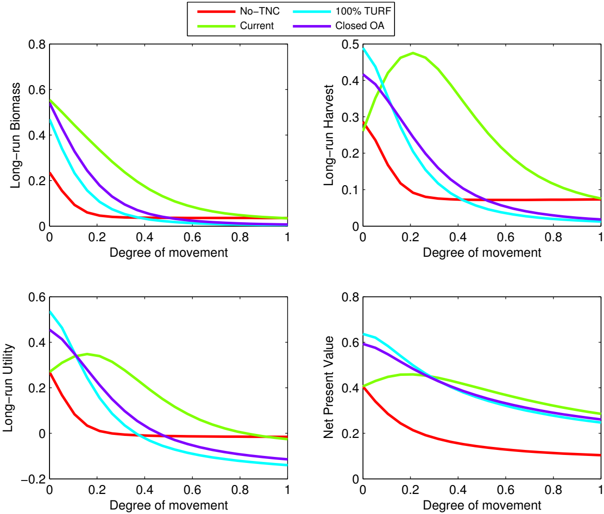
Cooperation

- Cooperation between agents increases significantly the efficiency of the system
- Open access diminishes performance
- MPAs can be justified only as a way of decreasing open access

Importance of movement

- In reality, most stocks have some degree of movement over space
- Depending on the degree of movement, management strategies might have different results
- We evaluated different movement ranges to see how strategies perform

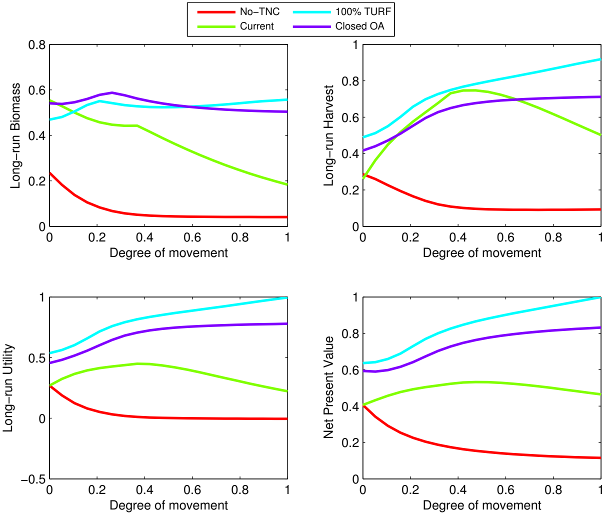
Movement and Competition



Movement and Competition

- MPAs reduce the number of competing agents and by association the losses of efficiency
- High degrees of movement increase the losses by competition and open access
- TNC's intervention has a better performance in most of the movement scenarios

Movement and Cooperation



Movement and Cooperation

- There is a strong connection between initial biomass, productivity and movement in the long-run performance
- Open access has a significant negative effect
- Higher degrees of movement have ambiguous effects depending on the spatial settings
- TNC's intervention might be considered as appropriate, but not necessarily preferred over other approaches

Conclusions

- Implementation of TURFs and/or MPAs does not necessarily guarantee optimal outcomes in the long-run
- However, combination of both strategies has significant benefits for competitive scenarios
- The gains from cooperation are significantly higher, as long as open access is under control

Conclusions

- Initial conditions and movement range have strong influence over long-run performance
- The combination of both TURFs and MPAs is preferred as long as there is enough movement
- Higher ranges of movement require cooperation to improve performance in the long-run

Thank you!