Implications of Spatial Management of TURFs and MPAs for Interconnected Marine Systems
The case of Chaihuín in Valdivia, Chile

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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

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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
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**

$$X_{i,t} = S_{i,t} - H_{i,t} \quad (1)$$

**Growth**

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

**Movement**

$$S_{i,t+1} = \sum_j D_{j,i} G(X_{j,t}) \quad (3)$$
For patch $i$ at time $t$:

**Profit**

$$\Pi_{i,t} = pH_{i,t} - \int_{X_{i,t}}^{} \frac{\theta}{B} dB$$  \hspace{1cm} (4)

**Net present value**

$$J_i = \sum_{t=0}^{T} \beta^t (\Pi_{i,t})$$ \hspace{1cm} (5)

**Decision variable (Fishing mortality $F$)**

$$H_{i,t} = S_{i,t} F_i$$ \hspace{1cm} (6)
Spatial definitions

Open access:

\[ F_{i,t} = \frac{pS_{i,t} - \theta}{pS_{i,t}} \]  

(7)

Harvest rule for MPAs and TURFs:

\[
F_i \Rightarrow \begin{cases} 
\max_{F_i(F_j^*) \forall j \neq i} (J_i) & \text{Cooperative} \\
\max_{F_i \forall i} \sum_i (J_i) & \text{Competitive}
\end{cases}
\]

(8)
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

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Competitive Scenario

- No-TNC
- 100% TURF
- Current
- Closed OA

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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 V/S Cooperation

Movement

Introduction
Model
Results
Conclusions

Competition

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Cooperation

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[Graphs showing the relationship between Biomass and Long-run Harvest, Long-run Utility, and Net Present Value for different TURF scenarios: No-TNC, 100% TURF, Current, and Closed OA.]
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

- Long-run Biomass
- Long-run Harvest
- Long-run Utility
- Net Present Value

Graphs illustrating the impact of movement and competition on various economic and biological metrics. The graphs compare different scenarios:

- No-TNC
- 100% TURF
- Current
- Closed OA

These scenarios are depicted across different degrees of movement, showing variations in outcomes such as biomass, harvest, utility, and net present value.
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

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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.
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!