Improvements in marine spatial planning: the benefits of incorporating enforcement costs

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Restricted-use management zones

- No-take
- User rights

Spatial optimisation

- Terrestrial
  - National parks
- Marine
  - Minimize losses to fishers
- Limited economic analysis
Aim

• Incorporate more comprehensive economic analysis into a spatial optimisation model

• Determine impact of including direct and opportunity costs on optimal marine zoning

Direct costs = management or transaction costs

→ Enforcement
Chile

- 4,200 km of coastline
- Rich marine resources
- Top 10 in world fisheries landings

- 1989-1991 Fisheries law
  - Territorial user rights for fishing
Enforcement costs

Deterring poachers and enforcing catch restrictions:
- Costs vary spatially

<table>
<thead>
<tr>
<th>Costs m²/yr</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.002</td>
<td>0-1km</td>
</tr>
<tr>
<td>0.003</td>
<td>1-2km</td>
</tr>
<tr>
<td>0.004</td>
<td>2-3km</td>
</tr>
<tr>
<td>0.004</td>
<td>3-4km</td>
</tr>
<tr>
<td>0.005</td>
<td>4-5km</td>
</tr>
<tr>
<td>0.006</td>
<td>5-6km</td>
</tr>
<tr>
<td>0.007</td>
<td>6-7km</td>
</tr>
<tr>
<td>0.008</td>
<td>7-8km</td>
</tr>
</tbody>
</table>
Spatial optimisation model

• Allocate cells \((C_{i=1,\ldots,96})\) to management zones
  Open access, TURF, Enforced-TURF, No-take, Enforced-no-take

• Objective: Maximize revenue from fish caught
  \[
  \text{Revenue}_{C_i} = (\text{Price} \times \text{Number of fish which can be caught}) - \text{Enforcement costs}
  \]

• Subject to minimum abundance targets
  – Targets based on maximum abundance
Spatial optimisation model

• Multiple scenarios – impact of enforcement
  
  • No enforcement: \( a \rightarrow O, T, N \)
  
  • Enforcement, no cost: \( b \rightarrow O, T, ET, N, EN \)
  
  • Enforcement, cost: \( c \rightarrow O, T, ET, N, EN \rightarrow $$\)
Fisher revenue

Benefits of enforcement = Revenue scenario $b$ (Enforcement, no cost) - Revenue scenario $a$ (No enforcement)

![Bar chart showing revenue (US$'000) against abundance target (0%, 4%, 8%, 12%) with benefits indicated by dark blue bars.](image-url)
Fisher revenue

Costs of enforcement = Revenue scenario $b$
(Enforcement, no cost) - Revenue scenario $c$
(Enforcement and cost)
Fisher revenue

Costs of enforcement = Revenue scenario $b$
(Enforcement, no cost) - Revenue scenario $c$
(Enforcement and cost)
Fisher revenue

1. Enforcement costs negligible compared to benefits
2. Benefit Cost Ratios (BCRs) > 1

![Bar chart showing revenue and benefit-cost ratios at different abundance targets.](image)
Optimal spatial allocation

**Management zones**
- Open access
- TURF
- Enforced-TURF
- No-take
- Enforced no-take

**Abundance target:**
- 0%
- 10%
- 20%
- 30%
- 40%

**Locations:**
- Algarrobo
- El Quisco
- Las Cruces

**Scale:**
- Kilometers
- 0 2.5 5

The University of Western Australia
Sensitivity analysis - Enforcement costs

Allocation of study area %

Enforcement cost multiplier

Base case

Enforced-TURF

Open access

BCR
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BCR

Base case
Why don’t fishers enforce?

• Fishers don’t enforce TURFs that are far away
• But – there are net benefits from enforcement??
• Potential explanations
  – Fishers may under-estimate the benefits of enforcement
  – Fisher associations may lack capacity or authority
  – Other biological forces at work
  – Transaction costs of enforcement may be higher than we have modelled
Accounting for enforcement can improve marine management

1. Large benefits from enforcement, negligible costs
2. Costs have a spatial component and can be minimized