Package Evaluation by the Delay-Difference Model

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Outline of package evaluation
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2. Methods
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   - Method for partial sensitivity analysis
3. Results
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   - Base case region-wide results
   - Sensitivity analysis results
   - Invertebrate results
4. General insights

Preliminary Comments

- EDOM has the following features:
  - Equilibrium spatial biological model with adult and larval movement
  - Fishing fleet (uniform effort, opportunistic fishermen, economically optimized mgt.)
  - Multiple species
- Outputs
  - Spatial distribution of biomass, harvest, profit, sport effort by species
- Dynamical models extend and refine models that generated size/spacing guidelines.

Base Case Parameterization

- Base Case
  - 5 species (Lingcod, Cabezon, Black Rockfish, Canary Rockfish, California Halibut)
    - Home range radius (.5 km - 10 km)
    - S.D. Gaussian larval dispersal (10 km – 45 km)
  - Fishing effort outside reserves
    - “Good Management” (fleet model with F=.05)
    - “Poor Management” (fleet model with F=.10)
    - “Management Fails” (fleet model with F=.15)
    - “Optimized for Profit” (spatial optimization)
Summary of spatial biomass

- Under “Good Management”:
  - All packages tend to increase biomass, but some areas of decreased biomass.
  - Effects range from -20% to 110%

- Under “Management Fails”:
  - All packages significantly increase biomass nearly everywhere.
  - Effects range from -25% to 600%
Spatial Harvest (F=.15)

Summary of spatial harvest

- **Under “Good Management”:**
  - Equilibrium harvest increases in some areas (spillover) and decreases in others (reserve)
  - Harvest increases in: 63% of patches (JC) to 75% of patches (XA and JD), decreases in complement.

- **Under “Management Fails”:**
  - Harvest can be significantly higher in certain open locations
  - Harvest increases in: 54% of patches (JD) to 59% of patches (XA), decreases in complement.

Biomass vs. Economics (F=.05)

Biomass vs. Economics (F=.15)
Biomass vs. Economics (Optimized for Economic Profit)

How bad does management have to be?
- For good management, all packages will impose an economic cost, and will increase fish biomass.
- For severely failed management all packages will increase biomass and economic value.
- How bad does management have to be to achieve this win-win?
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Equilibrium Biomass vs Equilibrium Economic Value for different F values:
- F = 0.07
- F = 0.08
- F = 0.09
- F = 0.1

None of the points are shown to be economically viable for the given F values.
How bad does management have to be?

- If $F > 0.06$, all packages are win-win from economic and biological point of view.
- JC always dominate biological outcome.
- For pretty bad management (.06-.08) JD and XA dominate economics.
- For management fails JC dominates both.

The more overfished you think the fishery will be in the future, the more you should like JC (goes for fishermen and conservationists).
Home Range (species-by-species)

<table>
<thead>
<tr>
<th>Species</th>
<th>Multiplier (Composite E = .05)</th>
<th>Multiplier (Lingcod E = .05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Canary</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Cabezon</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Home Range</td>
<td>0.75</td>
<td>1</td>
</tr>
</tbody>
</table>

Sensitivity to Home Range (F = .1)

<table>
<thead>
<tr>
<th>Species</th>
<th>Multiplier (Composite Biomass E = .1)</th>
<th>Multiplier (Fishery Value E = .1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>0.75</td>
<td>2</td>
</tr>
<tr>
<td>Canary</td>
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<td>2</td>
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<tr>
<td>Cabezon</td>
<td>0.75</td>
<td>2</td>
</tr>
<tr>
<td>Home Range</td>
<td>0.75</td>
<td>2</td>
</tr>
</tbody>
</table>

Sensitivity to Larval Dispersal Distance (F = .05)

<table>
<thead>
<tr>
<th>Species</th>
<th>Multiplier (Composite Biomass E = .05)</th>
<th>Multiplier (Fishery Value E = .05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>0.75</td>
<td>2</td>
</tr>
<tr>
<td>Canary</td>
<td>0.75</td>
<td>2</td>
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<tr>
<td>Cabezon</td>
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<td>2</td>
</tr>
<tr>
<td>Home Range</td>
<td>0.75</td>
<td>2</td>
</tr>
</tbody>
</table>

Ranking of policies for biomass is insensitive to Larval Range Multiplier.
General Conclusions

- If overall abundance is the objective, JC dominates under all fisheries scenarios.
- MPAs may reduce biomass of sandy-bottom species in a multi-species fishery.
- Spatial biomass can decrease in some areas, may increase by 6-fold with MPAs (under mgt. fails).
- Economic losses turn to gains for $F>0.06$.
  - Severely underfished: losses of up to 20% (JC most harm, but little difference)
  - Well managed: losses of up to 15% (all packages close)
  - Severely overfished: gains of up to 200%-300% (JC largest benefit)
- If tradeoff considered, good packages depend on fishing assumption outside:
  - "Good Management": JC (high fish, low econ), JD/XA (med fish, med econ) are reasonable
  - "Management Fails": All packages dominate no action in both dimensions. JC best.
- Improved fishery management can significantly reduce any economic damage from MLPAs.
- Ranking of policies for biomass (by species or composite) insensitive to home range, larval dispersal, robust to assumptions about $F$.
- Some very short dispersers (inverts) will still benefit biologically from MPAs but may not benefit economically, even under mgt. fails.
- If value to recreational sector measured by equilibrium Effort, all packages increase benefits to that sector.