

Fleet Models for the Marine Life Protection Act

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Why do we need a fleet model?

- Biomass dynamic models seek to predict ecological effects of regional marine protected area (MPA) proposals
 - Space is broken into 1 km² discrete “patches”
- Ecological effects depend on spatial fishing effort outside MPAs
 - How is effort currently distributed?
 - Where will effort go after MPAs implemented?

How do fleets behave?

- “Effort” = time fishing to achieve given fishing mortality
- Spatial fishing effort responds to:
 - Fish densities (adult biomass)
 - Distance from port
 - Fishing conditions/weather
 - Others’ fishing effort in the patch
- Effect of each variable may differ across:
 - Fleets (commercial, recreational)
 - Species

“Value” of fishing a patch

$$\pi_i = \alpha_1 f(E_i, B_{i0}) - [\alpha_2 D_i + \alpha_3 W_i + \alpha_4] E_i$$

- Where
 - i indexes a patch
 - B is current adult biomass
 - E is effort
 - $f(B, E)$ is harvest
 - D is distance
 - W is weather
 - $\alpha_1, \dots, \alpha_4$ are parameters

How is effort distributed?

- We assume fishermen choose to fish the patches that will return highest value

- Marginal value is:

$$\frac{\partial \pi_i}{\partial E_i} = \alpha_1 f'(E_i, B_{i0}) - \alpha_2 D_i - \alpha_3 W_i - \alpha_4$$

- All fished patches have equimarginal value

Fitting model parameters

- How do we know the value of the parameters $\alpha_1, \dots, \alpha_4$?
 1. Assume values for $\alpha_1, \dots, \alpha_4$
 2. Find patch-specific effort that satisfies equi-marginal value
 3. Find associate value for each patch
 4. Compare prediction with data
 5. Repeat to choose $\alpha_1, \dots, \alpha_4$ to optimize fit to data.

Objective Function

$$\sum_{i=1}^N \left(\frac{\pi_i(\alpha_1, \dots, \alpha_4)}{\sum \pi_i(\alpha_1, \dots, \alpha_4)} - \frac{\psi_i}{\sum \psi_i} \right)^2$$

Sum Over all Patches

Modeled Value from patch i
(as share of total value)

Observed Value from patch i
(as share of total value) from
EcoTrust

Sum Squared
Deviations

Summary

- To predict ecological effects of MPAs, we need a fleet model
- We'd like fleet model to: (1) accord with basic principles, (2) match effort distribution data under current conditions, (3) provide means of predicting fleet movement under any regional MPA proposal
- Our procedure generates a fleet model that is consistent with principles, existing data
 - But can also be used to forecast fleet changes under MPAs