A Model to Evaluate Sustainability and Yield of Proposed MPA Plans

UC Davis SAT Tools Contract

Loo Botsford
Will White
Liz Moffitt
Doug Fischer

RLFF
What is Sustainability?

The ability of a population to avoid collapse.

The same as:

- Persistence
- Resilience
- Biomass
- Fraction of coastline persistent
- Total larval supply
Why model Sustainability?

All MLPA goals require Population Sustainability

Our models will show the BRTF the effect of proposed MPAs on population sustainability
What is yield?

Total fishery catch of a species in the NCC Region
Why model Yield?

So the BRTF can account for the economic impact of proposed MPAs on fisheries
What does this model do?

BRTF needs to know difference between ‘no action’ and the effects of MPA packages

Our model summarizes long-term benefits and costs of each package, in terms of

• Sustainability
• Yield

(For five representative species)
What assumptions does it make?

- Larval dispersal patterns, by species
- Adults move within a home range
- When larvae settle, only a certain maximum number can recruit at each location in each year
  
  Constant effort (others can be used)

- Status of species (fishing/overfishing, e.g. BRF)
  
  not overfished  overfished  heavily overfished
What data does it use?

- Fishing mortality rate
- Natural mortality rate
- Growth rate
- Fecundity (number of offspring produced)
- Distribution of hard bottom habitat
- Location & regulations of proposed MPAs
## Species Considered

<table>
<thead>
<tr>
<th>Species</th>
<th>Average larval dispersal distance (km)</th>
<th>Average homerange size (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abalone</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Black Rockfish</td>
<td>40</td>
<td>9</td>
</tr>
<tr>
<td>Cabezon</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>Lingcod</td>
<td>35</td>
<td>9</td>
</tr>
<tr>
<td>Canary Rockfish</td>
<td>40</td>
<td>14</td>
</tr>
</tbody>
</table>

Images of the species are provided for reference.
Use one-dimensional strip along coastline
One-dimensional map
Long-term sustainability and yield for overfished case

Package ‘EC’, Overfished

Cabezon (larval dispersal = 100 km)

Abalone (larval dispersal = 1 km)

Hard-bottom habitat (no MPA)

Hard-bottom habitat + MPA
Example: summarizing results across NCC region

![Graph showing yield (relative to MSY) versus sustainability (relative to unfished) for different species and actions.](image)

- **No Action**: Black circles
- **EC**: Black triangles
- **JD**: Black diamonds
- **TC**: Black squares
- **JC**: Black inverted triangles
- **Abalone**: Purple circles
- **Cabezon**: Blue circles
- **BlackRockfish**: Red circles
- **Lingcod**: Green circles
- **CanaryRockfish**: Pink circles
Effects of uncertainty in stock status

Heavily Overfished

Overfished

Not Overfished

Yield (relative to MSY) vs Sustainability (relative to unfished)

- Abalone
- Cabezon
- BlackRockfish
- Lingcod
- CanaryRockfish

- No Action
- EC
- JD
- TC
- JC
Quantify differences between Proposals and “No Action”
Effects on each species: heavily overfished

![Graph showing effects on species](image)
Effects on each species: less overfished
Effects on each species: not overfished
Summary: range of uncertainty in stock status

Summed across species
Moving beyond 5 focal species

No Action; Overfished
Moving beyond 5 focal species

Package EC; Overfished
Further work needed

What is overfishing status of each of these species?

Effects of effort shift

Two-dimensional model.

Continue working on combination with MARXAN

Fast version with graphical user interface???

Present results with fishery management changed to optimize catch???
Conclusions

• MLPA goals require population sustainability

• Our model shows BRTF effects of MPAs on
  • Sustainability
  • Yield

• Results for 5 species + other ‘generic’ species

• MPA impacts depend on current population status
  • Considerable uncertainty about current status
Black Rockfish Landings

Figure 2. Base landings history for black rockfish off Oregon and California.

Landings (MTs) by fishery - Oregon.

Landings (MTs) by fishery - California.

from Sampson (2007) Black Rockfish Stock Assessment
Black Rockfish Catch Per Unit Effort (CPUE)

from Sampson (2007) Black Rockfish Stock Assessment
Recent decline in predicted Black Rockfish spawning output

Figure 29. Preliminary base-run model spawning output relative to unexploited.

from Sampson (2007) Black Rockfish Stock Assessment