A Model to Evaluate Sustainability and Yield of Proposed MPA Plans II

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Outline

• FLEP and overfishing review
• Sustainability vs. movement
• Spatial distribution plots & RSG
• Sustainability/Yield plots
• Overfishing status
• Sustainability and Yield vs. OF status
Points

Sustainability/Yield trade-off

Effects of Uncertainty

Use by stakeholders
Sustainability

The ability of a population to avoid collapse.

All MLPA goals require Population Sustainability

Yield

Total fishery catch of a species in the NCC Region

So the BRTF can account for the economic impact of proposed MPAs on fisheries
Important assumption-Overfishing?

What will management be outside MPAs?

Represented as ability of an individuals to replace themselves (i.e. population growing or declining?)

Fraction of Lifetime Egg Production (FLEP)
Lifetime Egg Production (LEP) = a measure of replacement

Sustainability requires that individuals in a population replace themselves in their lifetime.

In humans, a couple replaces themselves with 2 babies.

How many eggs does it take to replace one fish?
How much LEP is enough for individuals to replace themselves?

We express this as a Fraction of natural, unfished LEP (i.e., FLEP)

From examples where we have data, we can calculate a Critical Replacement Threshold (CRT):

- 35% (Clark 1991)
- 30% (Mace and Sissenwine 1993)
- 40% (Clark 1993, Mace 1994)
- 55-60% (Dorn 2002, for rockfishes)
Calculations re: FLEP and CRT

- FLEP
  - CRT = 0.35
  - Overfished
  - Not Overfished

Values:
- FLEP
  - 0.4
  - 0.3
  - 0.2
<table>
<thead>
<tr>
<th>Species</th>
<th>Average larval dispersal distance (km)</th>
<th>Average homerrange diameter (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>6</td>
</tr>
<tr>
<td>Cabezon</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>Lingcod</td>
<td>35</td>
<td>15</td>
</tr>
<tr>
<td>Canary Rockfish</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>California Halibut</td>
<td>45</td>
<td>30</td>
</tr>
<tr>
<td>Dungeness Crab</td>
<td>75</td>
<td>14</td>
</tr>
<tr>
<td>Red Sea Urchin</td>
<td>50</td>
<td>1</td>
</tr>
</tbody>
</table>

*Tracy Clark*  
*jyles - diver.net*
## Fish Home Ranges
(diameter in km)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>&lt; 2</th>
<th>&lt; 6</th>
<th>&lt; 10</th>
<th>10 – 20</th>
<th>20 – 40</th>
<th>&gt; 40</th>
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</thead>
<tbody>
<tr>
<td>kelp greenling</td>
<td>cabezon</td>
<td>black rf</td>
<td>yelloweye rf</td>
<td>lingcod</td>
<td>yellowtail rf</td>
<td>bocaccio rf</td>
<td></td>
</tr>
<tr>
<td>rock greenling</td>
<td>wolf eel</td>
<td>china rf</td>
<td>olive rf</td>
<td>blue rf</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>monkey face eel</td>
<td>brown rf</td>
<td>copper rf</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rock prickleback</td>
<td>gopher rf</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>black &amp; yellow rf</td>
<td>grass rf</td>
<td>quillback rf</td>
<td>starry rf</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kelp rf</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>black perch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>striped perch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### To be determined:
- rock sole
- rainbow perch
- rubberlip perch
- shiner perch

### Don’t know:
- bank rf
- calico rf
- chilipepper rf
- flag rf
- greenstriped rf
- rosy rf
- speckled rf
- squarespot rf
- widow rf

(after Freiwald, unpublished dissertation)
Hard Bottom; Package JD; Overfished (FLEP = 0.3)

Sustainability

Home range size (km)  Larval dispersal distance (km)

Abalone  BlackRockfish  Cabezon  Lingcod
Hard Bottom; Package XA; Overfished (FLEP = 0.3)

Sustainability

Home range size (km)

Larval dispersal distance (km)

Abalone

Black Rockfish

Cabezon

Lingcod
One-dimensional map
Canary Rockfish - Sustainability

CanaryRockfish
- FLEP = 0.4
- FLEP = 0.3
- FLEP = 0.2

No Action

JD

EC

TC

JC

XA

Distance Along Coast (km)

Sustainability
Canary Rockfish - Yield

Canary Rockfish

- FLEP = 0.4
- FLEP = 0.3
- FLEP = 0.2

No Action

JD

EC

TC

JC

XA
California Halibut - Sustainability

CaHalibut
- FLEP = 0.4
- FLEP = 0.3
- FLEP = 0.2

No Action

JD

EC

TC

JC

XA

Distance Along Coast (km)

Sustainability

[Graphs showing sustainability over distance along the coast for different scenarios and locations]
California Halibut - Yield

CaHalibut
- FLEP = 0.4
- FLEP = 0.3
- FLEP = 0.2

No Action

JD

JC

EC

TC

XA

Distance Along Coast (km)
How to improve sustainability?

CanaryRockfish

FLEP = 0.4
FLEP = 0.3
FLEP = 0.2

No Action

EC

JD

TC

JC

XA

Sustainability

Distance Along Coast (km)
How to improve sustainability?
How to improve sustainability?

**Canary/Rockfish**
- FLEP = 0.4
- FLEP = 0.3
- FLEP = 0.2

**Graphs**
- No Action
- EC
- JD
- TC
- JC
- XA

**Axes**
- Sustainability
- Distance Along Coast (km)

**Legend**
- Black line
- Blue line
- Red line
How to improve sustainability?
How to improve sustainability?

RedSeaUrchin

- FLEP = 0.4
- FLEP = 0.3
- FLEP = 0.2

No Action

EC

JD

TC

JC

XA

Distance Along Coast (km)

Sustainability
How to improve sustainability?

RedSeaUrchin

- FLEP = 0.4
- FLEP = 0.3
- FLEP = 0.2

No Action

JD

EC

TC

JC

XA

Distance Along Coast (km)

Distance Along Coast (km)
Sustainability and Yield Plots
To calculate improvement, we need to know FLEP and CRT by species.

Both are uncertain, but we do know something.
## Species values of FLEP and assumed CRT

<table>
<thead>
<tr>
<th>Species</th>
<th>CRT-UCD Model</th>
<th>CRT-EDOM</th>
<th>CRT-NMFS</th>
<th>FLEP UCD Est.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abalone</td>
<td>.35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black Rockfish</td>
<td>.35</td>
<td>0.5</td>
<td>0.17</td>
<td>0.13 (UCD)</td>
</tr>
<tr>
<td>Cabezon</td>
<td>.35</td>
<td>0.2</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Lingcod</td>
<td>.35</td>
<td>0.1</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Canary Rockfish</td>
<td>.35</td>
<td>0.05</td>
<td>0.25, 0.5</td>
<td></td>
</tr>
<tr>
<td>California Halibut</td>
<td>.35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dungeness Crab</td>
<td>.35</td>
<td></td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td>Red Sea Urchin</td>
<td>.35</td>
<td></td>
<td></td>
<td>0.17 (UCD)</td>
</tr>
</tbody>
</table>
Few estimates of FLEP, therefore we take a decision analysis approach

Based on available information, estimate probability that FLEP has certain values.
FLEP - Red Abalone

Last abalone stock not overfished in CA serial depletion
MPAs mentioned in recovery
No stock assessment

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not overfishing (FLEP=0.4)</td>
<td>0.5</td>
</tr>
<tr>
<td>Overfishing (FLEP=0.3)</td>
<td>0.25</td>
</tr>
<tr>
<td>Heavy Overfishing (FLEP=0.2)</td>
<td>0.25</td>
</tr>
</tbody>
</table>
FLEP-Black Rockfish

FLEP=0.13, estimated from local size distributions

Catch declining (see Stock Assessment)

CPUE declining (see Stock Assessment)

<table>
<thead>
<tr>
<th>How likely</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Not overfishing (FLEP=0.4)</td>
<td>0.2</td>
</tr>
<tr>
<td>Overfishing (FLEP=0.3)</td>
<td>0.3</td>
</tr>
<tr>
<td>Heavy Overfishing (FLEP=0.2)</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Black Rockfish Landings

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

Figure 14: RecFIN CPUE abundance indices (continued).

California Predicted RecFIN CPUE components for Model=6, Wave=4, and County=23

Delta-Lognormal CPUE index +/- 1.0 SE

from Sampson (2007) Black Rockfish Stock Assessment
FLEP - Cabezon

Biomass in long-term decline

Biomass currently at 34.7% $B_0$  $0.25B_0 < B < 0.4B_0$

Mode of 20 year projection = No Change

<table>
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<tr>
<th>Mode</th>
<th>How likely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not overfishing (FLEP=0.4)</td>
<td>0.2</td>
</tr>
<tr>
<td>Overfishing (FLEP=0.3)</td>
<td>0.4</td>
</tr>
<tr>
<td>Heavy Overfishing (FLEP=0.2)</td>
<td>0.4</td>
</tr>
</tbody>
</table>
Cabezon Biomass and Catch

![Graph showing Cabezon Biomass and Catch over years]

- **Spawning Biomass**
- **Total Catch**

Y-axis: Spawning Biomass (mt), Total Catch (mt)
X-axis: Years (1930-2010)

The graph illustrates the decline in spawning biomass over time, with fluctuations in total catch.
FLEP - Lingcod

Southern stock (CA) biomass below overfished level

\[(0.24 \, B_0 < 0.25 \, B_0)\]

Southern stock (CA) CPUE declining.

How likely

<table>
<thead>
<tr>
<th>Description</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not overfishing (FLEP=0.4)</td>
<td>0.2</td>
</tr>
<tr>
<td>Overfishing (FLEP=0.3)</td>
<td>0.4</td>
</tr>
<tr>
<td>Heavy Overfishing (FLEP=0.2)</td>
<td>0.4</td>
</tr>
</tbody>
</table>
Lingcod CPUE

Southern stock (CA)
FLEP - Canary Rockfish

Remains overfished, $B \sim 0.1B_0$

Recreational catch now 60% (up from 6%)

<table>
<thead>
<tr>
<th>Situation</th>
<th>Likelihood</th>
</tr>
</thead>
<tbody>
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<td>Not overfishing (FLEP=0.4)</td>
<td>0.2</td>
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<tr>
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<td>0.4</td>
</tr>
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<td>0.4</td>
</tr>
</tbody>
</table>
Canary rockfish spawning biomass \( B_0 \)
Weightings for each FLEP level informed by stock status
Overfishing weighting for each species from stock status
(other weightings possible)
All species heavily overfished (FLEP = 0.2)
All species overfished (FLEP = 0.3)
No species overfished (FLEP = 0.4)
Weightings follow NFMS/DFG overfishing status
Conclusions

In MPA improvements there is a complex tradeoff between Sustainability and Yield

The uncertainty in overfishing status needs to be accounted for, SAT can decide on weightings

Spatial distribution plots can guide RSG in adding or removing MPAs