SAT Evaluations of Draft MPA Proposals
North Central Coast Study Region

Presentation to the MLPA North Central Coast Regional Stakeholder Group
February 21, 2008 • San Rafael, CA
Presented by Dr. Mark Carr
MLPA Goals
Habitat Representation
Habitat Replication
Birds and Mammals
Size and Spacing (+ models)
MLPA Goals

1. To protect the natural diversity and function of marine ecosystems.
2. To help sustain and restore marine life populations.
3. To improve recreational, educational, and study opportunities in areas with minimal human disturbance.
4. To protect representative and unique marine life habitats.
5. Clear objectives, effective management, adequate enforcement, sound science.
6. To ensure that MPAs are designed and managed as a network.
MLPA Goals: Habitats

1. To protect the natural diversity and function of **marine ecosystems**.
2. To help sustain and restore **marine life populations**.
3. To improve **recreational, educational, and study opportunities** in areas with minimal human disturbance.
4. To protect representative and unique **marine life habitats**.
5. Clear objectives, effective management, adequate enforcement, sound science.
6. To ensure that MPAs are designed and managed as a **network**.
Key Questions for Each Proposal

1. How well are key habitat types represented in proposed MPA proposals?

2. What are the proposed levels of protection for these habitat types?

3. How well are habitats and levels of protection distributed across the study region?
<table>
<thead>
<tr>
<th>Level of Protection</th>
<th>MPA Types</th>
<th>Activities Associated with this Protection Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very high</td>
<td>SMR</td>
<td>No take</td>
</tr>
<tr>
<td>High</td>
<td>SMCA</td>
<td><em>salmon</em> (troll H&amp;L in water greater than 50m depth), <em>sardine</em>, <em>anchovy</em>, and <em>herring</em> (pelagic seine)</td>
</tr>
<tr>
<td>Mod-high</td>
<td>SMCA</td>
<td><em>salmon</em> (troll H&amp;L in water less than 50m depth)*, <em>Dungeness crab</em> (traps/pots), <em>squid</em> (pelagic seine)</td>
</tr>
<tr>
<td>Moderate</td>
<td>SMCA SMP</td>
<td><em>salmon</em> (non-troll H&amp;L), <em>abalone</em> (diving), <em>halibut</em>, <em>white seabass</em>, <em>striped bass</em>, <em>shore-based finfish and flatfishes</em> (H&amp;L), <em>clams</em> (hand harvest), <em>giant kelp</em> (hand harvest)</td>
</tr>
<tr>
<td>Low-mod</td>
<td>SMCA SMP</td>
<td><em>Urchin</em> (diving), <em>lingcod</em>, <em>cabezon</em>, <em>greenling</em>, <em>rockfish</em>, and <em>other reef fish</em> (H&amp;L), <em>surfperches</em> (H&amp;L), <em>mariculture</em></td>
</tr>
<tr>
<td>Low</td>
<td>SMCA SMP</td>
<td><em>bull kelp and mussels</em> (any method), <em>all trawling</em>, <em>giant kelp</em> (mechanical harvest)</td>
</tr>
</tbody>
</table>

* Note the BRTF voted to keep this mod-high LOP on Feb 14, 2008
Results: Habitat Representation

Similarities between proposals

- Similarities in number and location of MPAs as well as the habitats they include
- Size of MPAs varies
- Clusters of MPAs with an inshore SMR and offshore SMCA that allows various fishing activities
- Shoreline and shallow habitats are generally well represented in very high protection MPAs
estuarine habitats are generally well represented in very high protection MPAs

most proposals still protect a greater portion of these habitats in the south subregion (Drakes Estero)

In contrast to the last round, most proposals target small estuaries in both north and south
Results: Habitat Availability

Deep soft bottom is the most abundant habitat in all subregions.

More rocky shore and shallow rocky reef in the north subregion.

More shallow soft bottom in the south subregion.

Kelp is only mapped in the north subregion.

More estuarine area in the north, but more eelgrass in the south.
Shoreline Habitats

Most proposals have at least 20% of rocky shore and surfgrass at very high protection, while allowing some shorefishing, abalone and urchin harvest.

Protection of sandy beach is generally lower than protection of rocky shoreline.

Inclusion of mod-high protection affects sandy beach representation in 3 proposals (allow crabbing).
A high proportion of protected areas are in SMRs

Protection of kelp closely mirrors protection of shallow rock

Draft Proposal 4 (JC) protects the greatest proportion of all three rocky habitats above mod-high

Large areas of deep rock in **high** and **mod-high** protection due to salmon and crabbing

Some shallow rock and kelp areas in **moderate** due to shorefishing and abalone and **low** due to urchin harvest
Results: Habitat Representation

Soft Bottom Habitats

Lower representation of soft bottom habitats relative to rocky habitats

A high proportion of the protected shallow sand area is in SMRs

Some shallow sand areas in mod-high protection due to salmon and crab fishing

Large areas of deep sand in high protection due to deep water salmon trolling and mod-high protection due to crabbing

Low percentages but large areas of deep sand under protection
Results: Habitat Representation

Estuarine Habitats

Large proportions of estuarine habitats are included in SMRs

**Mod-high** protection is due to crabbing, **moderate** due to aquaculture
Results: Habitat Representation

Summary

- Some convergence among proposals in second round
- With the exception of estuarine habitats, proposals differed consistently across habitats in area protected (especially with high protection)
  
  \[ 4 > 1, 3 > 2, XA > 0 \]

- Many habitats are well represented in high levels of protection
- Habitats varied markedly in allowed uses and the relative representation of levels of protection

- Soft habitats still not as well represented as rock habitats
MLPA Goals: Populations

1. To protect the natural diversity and function of marine ecosystems.
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6. To ensure that MPAs are designed and managed as a network.
Results: Marine Birds

Breeding colonies by subregion
- **North**: Draft Proposal 3 covers most species/gross numbers
- **South**: Draft proposals 1 and 4 include most seabirds
- **Farallon Is**: Draft proposals 1, 3 and 4 include most seabirds

Seabird roosts by subregion
- **North**: Draft Proposal 3 includes most roosts
- **South**: Draft Proposal 1 includes most roosts
- **Farallon Is**: Draft proposals 1, 3, 4 and external A include most roosts

Seabird foraging areas by subregion
- Draft Proposal 3 rated highest and Draft Proposal 2 lowest
Results: Marine Mammals

Marine mammal rookeries by subregion

**North**: All draft proposals include 22-24% of pinnipeds, except Draft Proposal 3 (10%)

**South**: Draft proposals 1 and 3 include >90%

**Farallon Is**: Draft proposals 1, 3 and 4 include all (4 species) breeding pinnipeds (Draft Proposal 2 includes zero species and Draft External Proposal A includes two species).

Marine mammal haul-outs by subregion

**North**: Ranges from 8% (Draft Proposal 3) to 19% (Draft Proposal 1) of population in proposed MPAs

**South**: Draft proposals 1, 3 and 4 include >80% of pinnipeds

**Farallon Is**: All draft proposals include >96% of pinnipeds. All pinnipeds at haul-outs included except 50% of Steller sealion population in Draft Proposal 2 and Draft External Proposal A
Size Analysis Methods

- Measure individual MPA lengths and area
- Combine contiguous MPAs into single MPA complexes
- Consider level of protection
- Tabulate MPA lengths and areas relative to minimum & preferred guidelines
Cluster Sizes: Very High Protection

Below Minimum | At Minimum | Preferred Range
---|---|---
XA |  | 
4 (JC) |  |  
3 (TC) |  |  
2 (JD) |  |  
1 (EC) |  |  
Prop 0 |  |  

Size (sq mi)
Cluster Sizes: High Protection

Below Minimum | At Minimum | Preferred Range
---|---|---
XA | | |
4 (JC) | | |
3 (TC) | | |
2 (JD) | | |
1 (EC) | | |
Prop 0 | | |

Size (sq mi)
Cluster Sizes: Mod-high Protection

Below Minimum

At Minimum

Preferred Range

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Size (sq mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>XA</td>
<td></td>
</tr>
<tr>
<td>4 (JC)</td>
<td></td>
</tr>
<tr>
<td>3 (TC)</td>
<td></td>
</tr>
<tr>
<td>2 (JD)</td>
<td></td>
</tr>
<tr>
<td>1 (EC)</td>
<td></td>
</tr>
<tr>
<td>Prop 0</td>
<td></td>
</tr>
</tbody>
</table>

Cluster Sizes: Mod-high Protection

- Below Minimum
- At Minimum
- Preferred Range

Cluster sizes for XA, 4 (JC), 3 (TC), 2 (JD), 1 (EC), and Prop 0 are depicted on a graph showing size ranges.
With Very High Protection:

- Draft proposal 4 (67%) is the most consistent with the size guidelines. 4 has one reserve in the preferred size range.
- Draft proposals 3 (50%) and 1 (38%) have an intermediate fraction of reserves that meet the minimum size guidelines.
- Draft proposals 2 and external A have no marine reserves that meet the size guidelines.

With High Protection:

- All proposals increase the fraction of reserves that meet at least minimum guidelines.
- The ordering of proposals remains the same.
With **Moderate High Levels of Protection:**

- Nearly all MPA clusters in all proposals meet at least the minimum size guidelines.
- Draft Proposals 4 and 3 have the most MPA clusters in the preferred size range.
Spacing Analysis Methods

- MPAs must meet the minimum size guidelines (9 square miles) to count for spacing
- Characterize each MPA by the habitats included
- For each habitat, measure the gaps between adjacent MPAs
Max Gaps: Very High Protection

Beaches
Rocky shore
Surfgrass

soft 0 - 30m
soft 30 - 100m
hard 0 - 30m
hard 30 - 100m

SAT Guidelines

Maximum Gaps (mi)

Prop 0 1 (EC) 2 (JD) 3 (TC) 4 (JC) XA
Max Gaps: High Protection

Beaches
Rocky shore
Surfgrass

soft 0 - 30m
soft 30 - 100m
hard 0 - 30m
hard 30 - 100m

SAT Guidelines

Maximum Gaps (mi)
### Max Gaps: Moderate-high Protection

<table>
<thead>
<tr>
<th>Location</th>
<th>Beaches (0 - 30m)</th>
<th>Beaches (30 - 100m)</th>
<th>Rocky shore (0 - 30m)</th>
<th>Rocky shore (30 - 100m)</th>
<th>Surfgrass (0 - 30m)</th>
<th>Surfgrass (30 - 100m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prop 0</td>
<td>160</td>
<td>170</td>
<td>160</td>
<td>170</td>
<td>160</td>
<td>170</td>
</tr>
<tr>
<td>1 (EC)</td>
<td>50</td>
<td>60</td>
<td>50</td>
<td>60</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>2 (JD)</td>
<td>70</td>
<td>80</td>
<td>70</td>
<td>80</td>
<td>70</td>
<td>80</td>
</tr>
<tr>
<td>3 (TC)</td>
<td>80</td>
<td>90</td>
<td>80</td>
<td>90</td>
<td>80</td>
<td>90</td>
</tr>
<tr>
<td>4 (JC)</td>
<td>60</td>
<td>70</td>
<td>60</td>
<td>70</td>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td>XA</td>
<td>70</td>
<td>80</td>
<td>70</td>
<td>80</td>
<td>70</td>
<td>80</td>
</tr>
</tbody>
</table>

**SAT Guidelines**

- Beaches: Soft 0 - 30m, Soft 30 - 100m
- Rocky shore: Hard 0 - 30m, Hard 30 - 100m
- Surfgrass: Soft 0 - 30m, Soft 30 - 100m
With **Very High Protection**: 

- Draft proposals 4 and 3 were close to meeting the spacing guidelines for all habitats except deep sand.
- Draft proposals 1, 2 and external A greatly exceeded the spacing guidelines for all habitats. In this group, the maximum gaps for Draft Proposal 1 were consistently smaller than those for 2 and external A.

With **High Protection**: 

- All patterns remain unchanged *except* Draft Proposal 1 now meets the spacing guidelines for all habitats except sandy beach and deep sand.
With **Moderate High Levels of Protection**:

- Draft proposals 4, 3 and 1 meet the spacing guidelines for all habitats. Maximum gaps are in the middle of the recommended range for most habitats.
- Draft proposals 2 and external A meet the spacing guidelines for all habitats except two: sandy beaches and deep sand.
Methods: Habitat Replication

Guidelines for replication:

- MPA or cluster must meet the minimum size guidelines (9 square miles)

- Habitat must meet the threshold identified to encompass 90% of biodiversity in that habitat type

- Estuarine MPAs do not have to meet size guidelines but must contain at least 0.12 mi² of estuarine habitat

- Some small estuaries (Gualala and Garcia rivers, Pescadero Creek) contain less than the minimum 0.12 mi², but protection of these habitats still has conservation value
Replication: Very High Protection

- Beaches
- Rocky shores
- Surfgrass

- Soft 0 - 30m
- Soft 30 - 100m
- Hard 0 - 30m
- Hard 30 - 100m
- Average Kelp
- CCSR MPAs

(Number of Replicates)

- Prop 0
- 1 (EC)
- 2 (JD)
- 3 (TC)
- 4 (JC)
- XA
Replication: High Protection

- Beaches
- Rocky shores
- Surfgrass
- Soft 0 - 30m
- Soft 30 - 100m
- Hard 0 - 30m
- Hard 30 - 100m
- Average Kelp
- CCSR MPAs

Number of Replicates

Prop 0 | 1 (EC) | 2 (JD) | 3 (TC) | 4 (JC) | XA
Replication: Estuarine Habitats

Most habitats with 3-5 new replicates

Greater replication of eelgrass than CCSR

No estuarine habitats in mod-high or high LOP
Replication: Estuarine Habitats

Estuarine Replication No Minimum Size

- Estuary
- Marsh
- Eelgrass
- Tidal flats
- CCSR MPAs

- Prop 0
- 1 (EC)
- 2 (JD)
- 3 (TC)
- 4 (JC)
- XA

Estuaries too small to meet size criterion add conservation value

Additional replicates that meet habitat size criterion
Results: Habitat Replication

Summary

- Marked differences among proposals
- Generally less replication than MLPA Central Coast Study Region (CCSR) at highest levels of protection
- At the highest levels of protection, $4 > 1,3 > 2$, $X_A > 0$
- Fewer differences among proposals and more similar to CCSR at moderate-high levels of protection
- Estuarine habitats well replicated.
Evaluations with Models

- Two models: EDOM, UCD
- Equilibrium models predict the effects of MPAs into the future
- Models look at individual species and do not consider complex ecosystem interactions
- Levels of protection are not used in the models – instead protection is species by species
Model Designs

Both Models Assess

– Conservation value (abundance, sustainability)

– Economic return (yield, profit)

– Responses for multiple representative species

– Responses with different management actions

– Responses with different fishing behavior but currently fishing concentrates where fish are
## Example Species Considered

<table>
<thead>
<tr>
<th>Species</th>
<th>Average larval dispersal distance (km)</th>
<th>Average home range 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
Increasing size and decreasing spacing leads to greater conservation value.

Relationship between conservation value and economic return depends on what happens outside MPAs:

- Unsustainable harvest - MPAs increase both conservation value and economic returns.
- Sustainable harvest - tradeoff between conservation and economic return.
Spatial Forecasts of Abundance

Spatial Biomass Predictions (Gravity with $F=0.05$)

Distance from Northern Boundary

Spatial Biomass Predictions (Gravity with $F=0.05$)
Uses of Spatial Model Predictions

- Forecasts which configurations should lead to higher biomass or more sustainable populations (conservation value) and/or which lead to higher yield (economic return).

- Provide a basis for considering how to adjust MPA proposals to achieve desired conservation or economic results.
Results from EDOM Model

- XA
  - 4 (JC)
  - 3 (TC)
  - 2 (JD)
  - 1 (EC)
  - Prop 0

Abundance

- Sustainably Fished
- Mod Overfishing
- Heavy Overfishing
Results from UCD Model

- XA
- 4 (JC)
- 3 (TC)
- 2 (JD)
- 1 (EC)
- Prop 0

Legend:
- +: Sustainably Fished
- ○: Mod Overfishing
- □: Heavy Overfishing

Economic Value

0 0.2 0.4 0.6 0.8 1.0
Results from EDOM Model

Sustainably Fished
Mod Overfishing
Heavy Overfishing

EA
4 (JC)
3 (TC)
2 (JD)
1 (EC)
Prop 0

Economic Value
Results from UCD Model

- Sustainably Fished
- Mod Overfishing
- Heavy Overfishing

Conservation Value vs. Economic Value graph.
Results from EDOM Model

- Sustainably Fished
- Mod Overfishing
- Heavy Overfishing
Insensitivity to Some Assumptions

Composite Biomass ($E=1$)

Larval Range Multiplier
Fishery Value ($E=1$)

Larval Range Multiplier
Sensitivity to Others

% Difference from No Action

Fishing Pressure, F

None, XA, EC, JD, TC, JC
General Model Conclusions

Rank of proposals in terms of conservation value is relatively insensitive to:
- Species Differences
- Management Actions

Rank of proposals in terms of economic value strongly depends on management outside

System switches from win-win to predictable tradeoff