Spatial bioeconomic models for marine protected area network design

MLPA South Coast Study Region

Dr. Christopher Costello (UCSB)
Dr. Will White (UCD)

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Why models help inform good decisions

- How will a marine protected area (MPA) network affect the ecosystem and species that comprise it?
- Why bio**economic**? Does act require that we examine economics?
  - Ecological predictions depend on economic behavior
  - MPA performance depends on fishery management outside MPAs
  - Political viability depends on economic impact
- Southern California data to predict spatial effects of MPAs
  - Economic and ecological criteria for a range of target species/fleets
- Key attributes
  - Larval dispersal
  - Adult movement
  - Parameterize for range of life histories and habitat associations
  - Fleet behavior when implement MPAs

Spatial implications for conservation

- Complex interactions:
  - MPA size and placement interacts with habitat, dispersal, home ranges, fisheries behavior to create complex spatial consequences.
- Use spatially-explicit models to predict:
  - Biomass of different species across space
  - "Sustainability" of stock
  - Yield, Effort and Profit across space
  - Change from status quo

Innovations in progress

1. Oceanography-driven larval dispersal (from University of California, Santa Barbara/University of California, Los Angeles project)
2. Temporal variability in larval dispersal
3. Two-dimensional space
4. Integrate fleet model, bioeconomic model, and fishing effort surveys

Model Inputs

(University of California, Davis + University of California, Santa Barbara)

Geographic

- Habitat maps
- MPA boundaries & regulations

Species-specific

- Life history (growth, natural mortality, fecundity)*
- Adult movement (home range diameter)*
- Larval dispersal (PLD, spawning season, some behavior)
    - Determine dispersal patterns from UCLA/UCSB circulation model**
- Egg-recruit or settler-recruit relationship (critical to persistence)

Other

- Oceanographic regime (which year(s) of dispersal data to use?
- Spatial pattern of fishing effort outside MPAs

*Thanks to L. Allen, C. Lowe, J. Caselle, et al. for ecological data
** Thanks to D. Siegel, S. Mitarai, J. McWilliams, and colleagues for dispersal data

Species List

Species	Adult Homerange	Spawning Season	Pelagic Larval Duration (PLD)
Kelp Bass	< 1 km	May-June	30 d
Sheephead	< 1 km	June-Sept	37 d
Black Surfperch	< 1 km	April-June	n/a
Red Sea Urchin	< 1 km	Dec-Feb	50-120 d
Ocean Whitefish	***(in progress)***		
Kelp Rockfish			
Barred Sandbass			
CA Scorpionfish			
Spiny Lobster			
Kellet's whelk			
Owl limpet			

Model Outputs (UCD + UCSB)

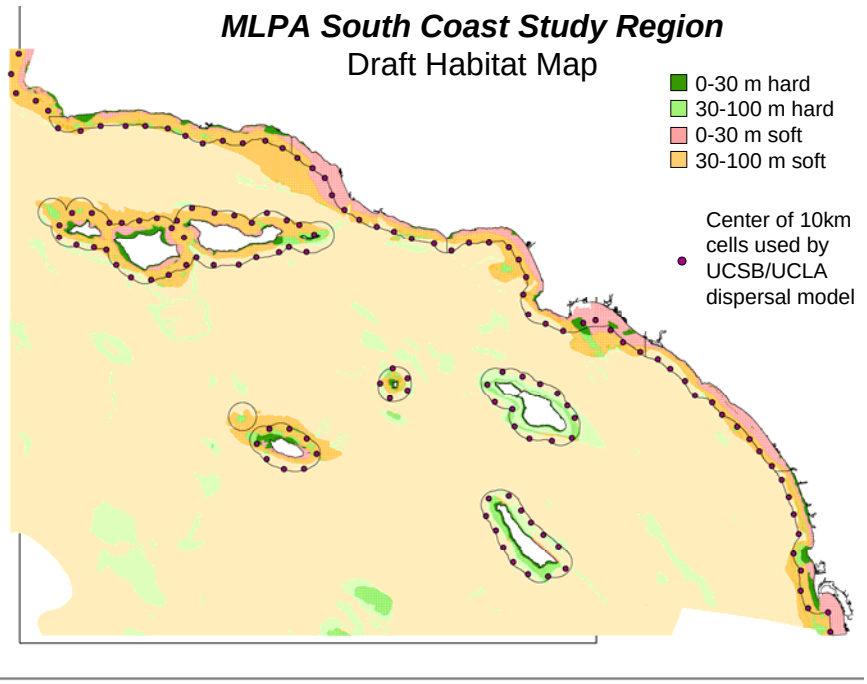
"Conservation"

- Spatial distribution of larval settlement & biomass
- Total settlement & biomass (summed over space)

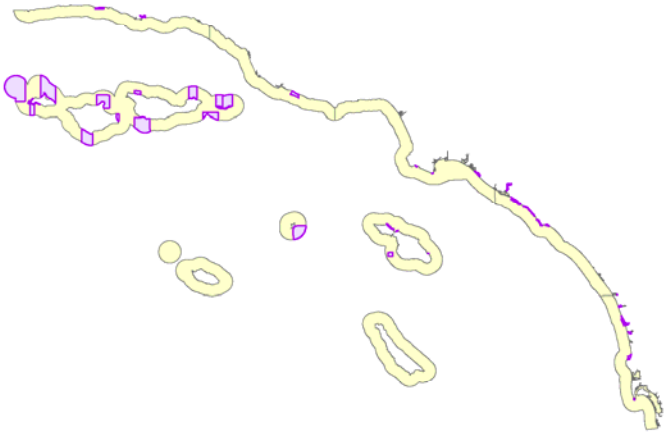
"Economic"

- Spatial distribution of yield
- Total yield (summed over study region), Total profit

- *Currently, outputs are based on long-term equilibria*
- *Transient responses are possible, but require estimates of initial population densities across space*

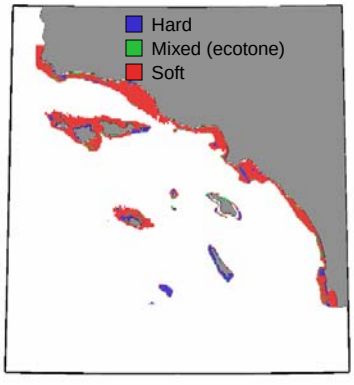


MLPA South Coast Study Region
Existing MPAs

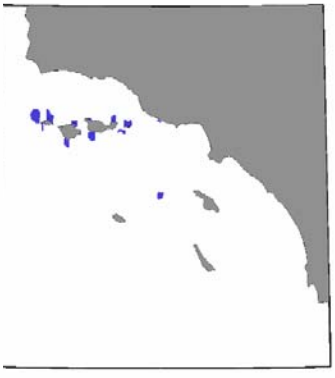


Models Convert Spatial Information to 1 km² Grid

Habitat

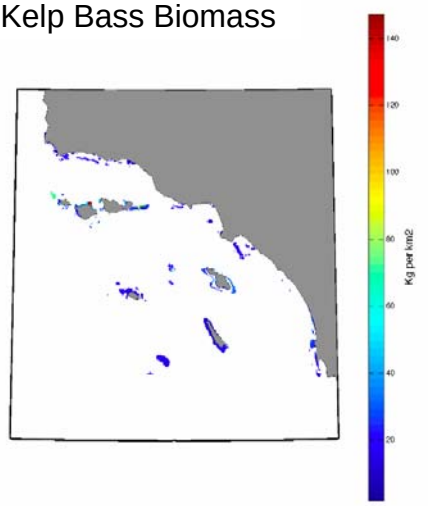


Existing MPAs

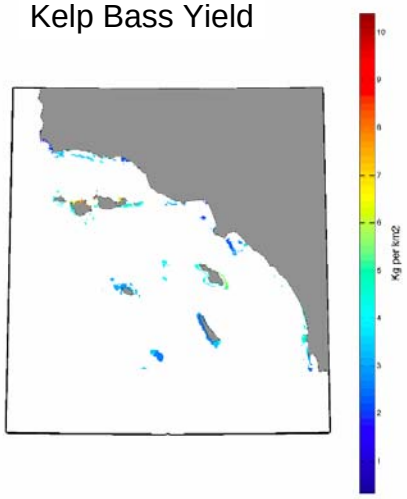


Example Results: Spatial Distributions
(UC Davis Model)

Kelp Bass Biomass



Kelp Bass Yield



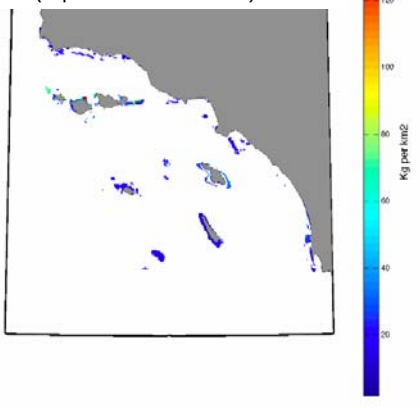
Disclaimer: preliminary example results only, may contain inaccuracies & artifacts

Example Results: Effect of variability in fishing/stock status

Response = Kelp Bass Biomass

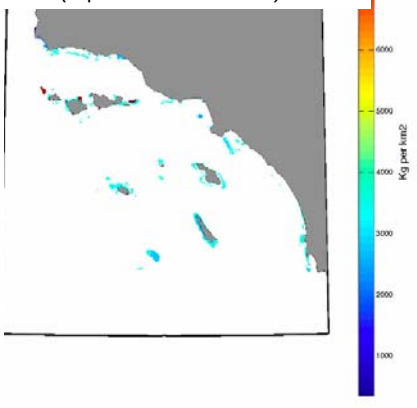
Heavy fishing
(unsustainable without MPAs)

FLEP = 0.3
*(*equivalent to *F* = 3.85)



Sustainable fishing
(populations persist without MPAs)

FLEP = 0.4
*(*equivalent to *F* = 0.68)



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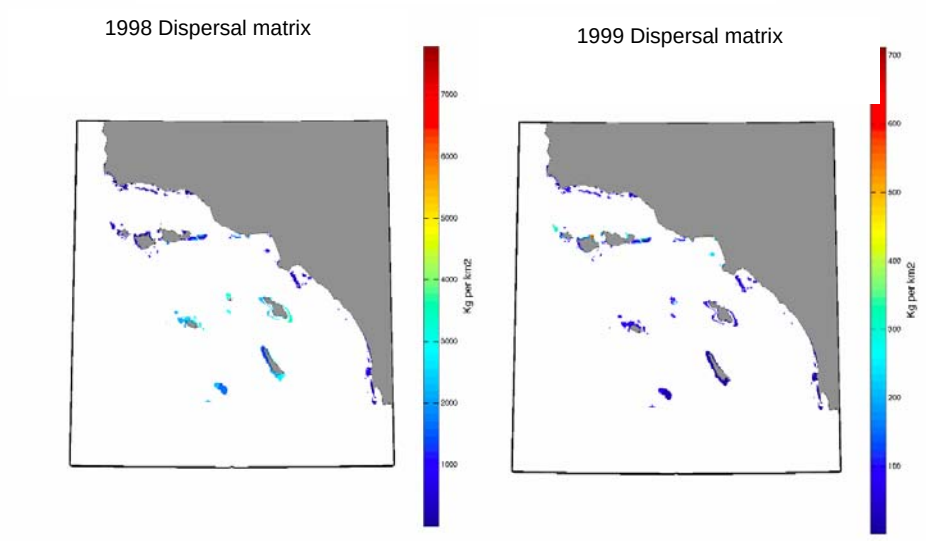
Example Results: Effect of variability in oceanography

Response = Kelp Bass Biomass

1998 Dispersal matrix

1999 Dispersal matrix



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Summarizing Results Across Space

- Evaluate conservation vs. economic tradeoffs
- Spatial summaries:
  - Conservation: total biomass, total larval settlement
  - Economic: total yield
- Summarize performance of each proposal under each set of fishery (and oceanographic?) conditions

Example: MLPA North Central Coast Study Region - Final Round

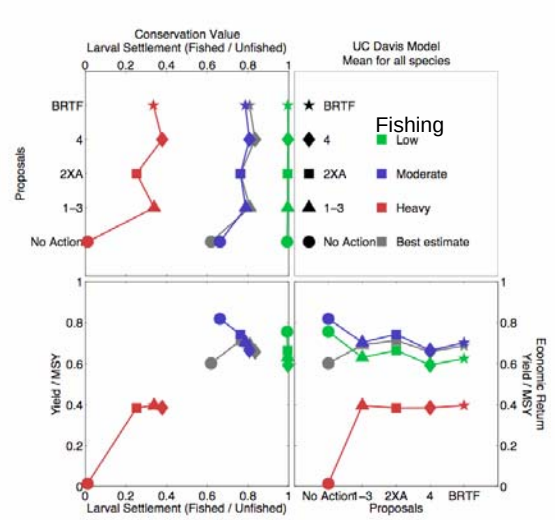
(UC Davis Model)

Conservation Value
(measured relative to unfished state)

Economic Value
(measured relative to maximum sustainable yield)

Three MPA proposals
+ "No Action"
+ BRTF proposal

Three possible fishery conditions
+ Best estimate based on current stock status (UCD)
+ Optimal yield solution (UCSB, not shown)



Example: MLPA North Central Coast Study Region - Final Round

Rescaled as difference from No Action

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(measured relative to unfished state)

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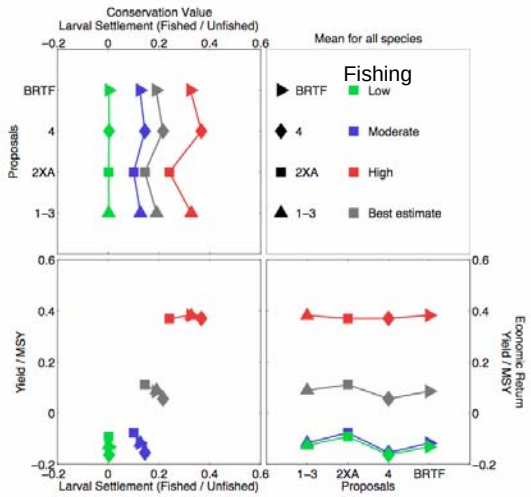

Rough timeline for progress

- ***Currently***
  - Sample output for range of species for baseline MPAs for simple fleet model
    - Equivalent to models used in NCCSR
- ***Late January***
  - Latest habitat, all species parameterized, interannual variability in dispersal (both UCD and UCSB models)
    - Equivalent to NCCSR models + better oceanography
  - Ready for candidate MPA networks
- ***Late February/Beginning March***
  - Fleet model parameterized with EcoTrust data
    - NCCSR models + better oceanography + better fleet dynamics
  - Evaluations of MPA networks can include more realistic economic component