A Synthetic Approach to the Science Of Ecosystem Based Management

Working Group Meeting 3 Notes

NCEAS, Santa Barbara, CA

January 27 – 30, 2007

January 27

Presentations – Subgroup Updates

A general framework for EBM – Mike Fogarty

Overall Objective: Define general strategy for an ecosystem approach to management focusing on diverse ecosystem services, societal preferences, and associated tradeoffs

- Illustrate with real world example(s) – test case
- First step – define the ecosystem services

The Problem

- Societal preferences are imperfectly known – specify utility functions (probability distribution for choices for weighing relative benefits for services)
- Ecosystem processes are incompletely known – uncertainty at a number of levels
- Data/Model limitations for some or all components

We need to

- Adopt risk assessment framework
- Adopt broad definition of models – (broader than dynamical framework or network model; could include statistical models and/or indicators)

Approach

- Identify key ecosystem services (Ca Current & Monterey Bay)
- Define objectives for management unit. (Objective function maximizes total value or utility, with a series of weights subject to societal preferences)
- Specify relationships among services, state variables, drivers, and control variables
- Models broadly defined
    - Dynamical models
    - Static models (e.g. Network Model)

  - Empirical predictors (e.g. state of ecosystem components)
  - Indicators
- Evaluate policy options

Define Objectives for Management

- e.g. Maximize values associated with different ecosystem services with different weighting coefficients
- Valuation V_i is a function of its valuation coefficient and a set of state variables (e.g. catch), driver variables (e.g. anthropogenic forcing), and control variables (e.g. management actions like harvesting)
- This model is not dynamic but rather the main set of control variables and drivers are known; simpler representation that could even collapse to a linear problem

$$\max \left\{ E\left(\sum_{i=1}^{n} w_i V_i \right) \right\} \qquad \textit{Subject to:} \quad V_i = f\left[v\left(X_i \mid Y_1, Y_2 ... Y_j, C_1, C_2 ... C_k \right) \right]$$

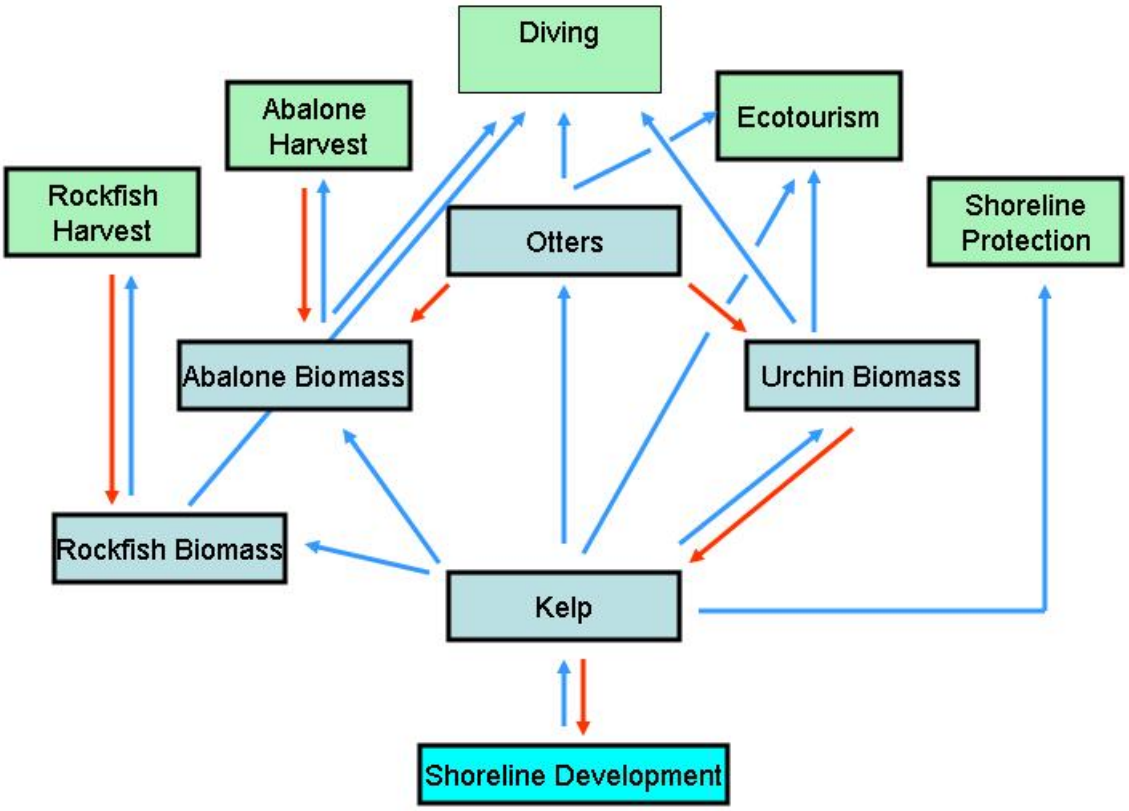
Ecosystem services we've targeted:

- Locally Caught Seafood (commercial)
- Sport Fishing
- Ecotourism
- Diving
- Shoreline Protection/Water Quality

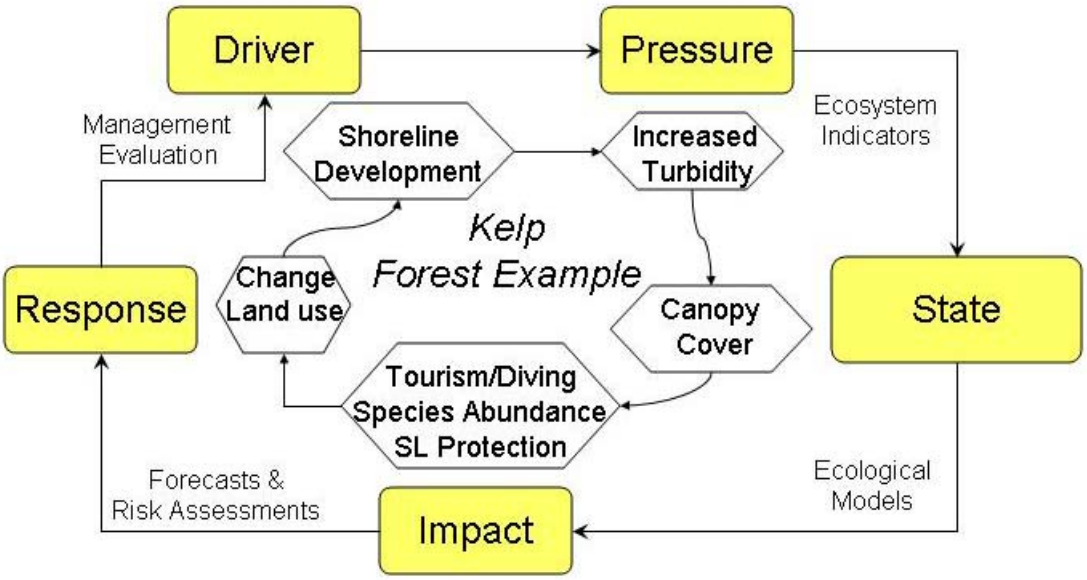
Drivers

- Shoreline Development
- Demand for Local Seafood
- Tourist Demand
- Diver Demand
- Recreational Demand
- Other Exogenous Drivers (e.g. Climate Forcing (ENSO))

Focusing on shoreline development as the driver



Kelp Forest Example



Real World Example

- Identify a choice that is relevant to society with sufficient understanding/data to allow reasonable evaluation of policy alternatives
- Possibility: Develop EBM Plan for Monterey Bay NMS?
    - High data availability & quality from MBNMS & MBARI, e.g. landings & price per vessel for certain species; time series of kelp cover; temperature anomalies for the bay over time; changes in primary production over time (anomalies), etc.
    - See Starr et al. report on Monterey Bay fisheries: Trends in Fisheries and Fishery Resources.

Conclusion

- Sufficient data/understanding available for MBNMS to warrant consideration for test case

Discussion

- A general framework for EBM
    - Is lacking
    - We could step back from subgroup efforts and try to produce that, i.e. an iterative process for how to do EBM.
    - The framework is highlighted by Mike's approach slide
    - Need to maintain the key features of EBM that make it different from sectoral or single species management
- Incorporating linkages
    - Exploring for interaction between services & sectors will be key
    - Simple to complicated dynamical models can be useful – as long as there are linkages between services or sectors
- Objective function definition
    - Need to be careful about how we define the services.
        - One possibility: Value the service and model it as being dependent on a set of anthropogenic and natural state variables (e.g. to maximize elements of the value of harvestable rockfish, one should include the commercial harvest value, the non-consumptive use value to divers, the recreational harvest value. Set the constraints for how much rockfish biomass you can remove based on the weights that society would attach to the different elements (i.e. how much you would allocate to different sectors).
        - As Mike has it written, the service is a state variable (e.g. catch – the provision of yield to commercial fishery)
        - But it is risky to define the service on one variable, because it makes it difficult to make predictions in terms of tradeoffs and it may mean that you lose the longer term view that would take into account multiple factors that have affected the activity in the past or might affect it in the future.
        - We should think of the variables as indicators of the service rather than the service itself. At different time points you may have different indicators.

        - In Susanne's framework, the activities are what are to be valued and regression is used to identify the variables that best explain variation in activity level.
        - The weighting variables are based on willingness to pay for a particular service, e.g. the desire to see large animals that won't eat me while I'm diving, (which might be expressed in aggregate biomass of these species).
    - Temporal considerations
        - Shifting baselines may cause real problems in defining the objective function. If value is based on current human activities and the current state of the ecosystem, we may make serious management mistakes because we can't anticipate changes in preferences (e.g. monkfish used to be considered a trash fish and now is highly prized) and/or in our understanding of the dynamics of the system.
        - Can include option value for species that currently are not valued by human users to accommodate shifting preferences.
        - Restricting ourselves to realized and potential benefits we can include them in Mike's model in terms of weights that are given to different services which can incorporate option value. As long as we include V for all realized and potential benefits.
        - Option value can get at the potential value of a service that is lost as the result of another activity. e.g. lost potential recreational value from dam; loss of potential service from discards of another species' catch
    - Intrinsic value
        - Should be excluded from economic valuation.
        - However, valuation can encompass a broad range of services, as long as they can be linked back to a specific human use or to human well being in a way that can be valued, e.g. fantasy value.
    - Indicators
        - In the absence of a dynamical model that considers all of the linkages in the system, indicators may reflect what some of the drivers are and then from there we can address the resulting pressures. Pressures would then feedback to change the state of the indicators.

Path analysis for exploring EBM science frameworks – Andy Rosenberg

General introduction to path analysis

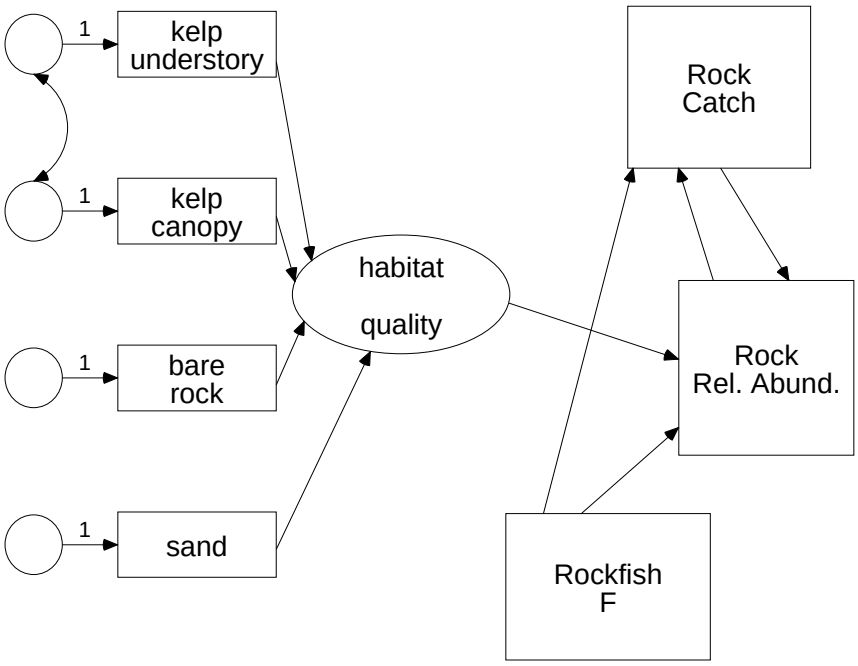
- Linear models between observed and/or latent variables
- Include direct and indirect effects
- Exploratory path analysis and confirmatory factor analysis, used for hypothesis testing and model comparison
- Test relationships on correlation or covariance matrix: if all variables are standardized, the correlation matrix is used and relative interaction strengths can be compared; if variables are not standardized, the covariance matrix is used.
- Software – Lisrel (Maximum likelihood methods), Amos (more user friendly and exploratory)

- Causal pathways – coefficients are interpreted in a directional not just correlational sense
- Historically this has been used in social science where people ask interview questions that relate to difficult to measure latent variables and concepts (e.g. self-worth).

Latent variables

- Unobserved constructs that are key features of the system
- Could be used to define services (conceptual issues is how are services defined or treated)
- Observed variables can be affected by latent variables or vice versa OR observed variables are expressions of latent variables with some error
- E.g in fisheries science – latent variable is stock size (landings (~catch + error) and effort are observed and stock size is estimated from those)

Attempted data exploration exercise

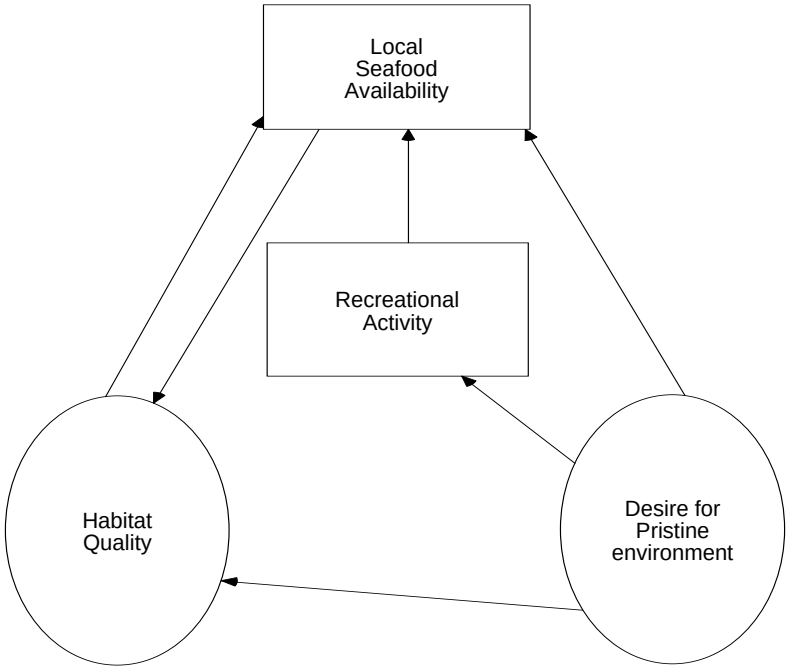


- Ellipses are latent variables.
- Rectangles are observed variables.
- Each arrow is a causal relationship (thought of as a regression coefficient).
- Two-headed arrows are correlations (not necessarily directional) – drawn on residuals which suggests that they are correlated through residuals (via some other effect?)
- Policy may be to protect habitat quality, but you don't actually measure habitat quality – measure attributes of that (the four variables here plus some other residual error that indicates other unobserved variables).
- Not all latent variables represent ecosystem services. Habitat quality could be defined as an ecosystem service (supporting service in Millenium Assessment) but it is not necessarily one here.

- Habitat quality here is defined by habitat for fish but habitat quality could be described for divers.
- Relationships between latent and observed variables can then be used to look at valuing the indirect effects and their relative magnitudes if you standardize the values, e.g. compare the direct effect of fisheries mortality on abundance vs. the indirect effects of mortality through catch on abundance.

Discussion

- Should we compare latent variables or just use direct relationships? E.g. don't need habitat quality to look at the effect of kelp cover on rockfish abundance.
- Latent construct provides an opportunity to bring together things – a way to create an indicator for example, that encompasses a lot of variables.



Latent variables

- Desire for pristine environment (may be valued through demand curves with error)
- This may affect habitat quality and local seafood availability (directly & indirectly through habitat quality or recreational activity)

Other thoughts on applying path analysis to EBM

- Can have feedback loops (non-recursive models) between latent and observed variables, but these make it more difficult to do calculations and require more data.
- Because of the linear structure, probably most appropriate for exploring interactions and feedback loops, not necessarily modeling generation of services; however, in some cases

this may be useful to explore a single service and for trying to determine explanatory variables
- Confirmatory factor analysis is less useful in our context because we are not trying to test hypotheses, but rather just explore interactions.
- There are an infinite number of diagrams, so we need to determine the critical indirect effects for exploration.
- Serious problem of statistically identifying parameters
- Need to have a more complete data set and work on replication issue – beyond time series data (include more spatial replication?)
- Useful model especially in light of the fact that direct and indirect effects are important to explore for EBM

Issues with using path analysis
- Big problem is constructing a useful dataset!!!
- Defining the services
- Is it worthwhile using the latent variable construct? Perhaps for indicator development, especially when dealing with multivariate observed variables. But unless we can value the latent variables then it may not be useful.

Data problems
- So far, have used DFG catch time series, aggregated by port and PISCO data on the relative abundance of various ecological components.
- Averaged across the 7-8 PISCO sites for 1 year (no spatial variability)
- Limited in what the habitat quality variables can be by PISCO sampling
- Kelp understory and kelp canopy are so highly correlated that couldn't get much out of the pathway
- Not many interesting paths at this point

Discussion
- Go to the MBNMS data & dive survey data
- Explore the analysis that Suzanne has done
- Indirect effects and feedbacks: can we get data to explore them?

Boundary Delineation – Carrie Kappel

Research questions
- What constitute areas of biophysical similarity within coastal marine environments of central California?
- How does data availability, resolution and type affect these patterns of biophysical similarity?
- What are the implications for the delineation of ecosystem boundaries for management (ultimately a political process)?

Steps in the analysis
- Identify data layers for inclusion
    - Static snapshot layers

    - Time series covering the same area for SST and chl a (remotely sensed)
- Convert layers to raster (grid) format so that multivariate statistics can be calculated on them.
- EOF of time series to identify major modes
- PCA to reduce the number of variables (combining static snapshots and results of EOF)
- Cluster analysis to determine areas of similarity

Progress to Date
- Data layers acquired (9km cells, 5 min grids)
- Data layers still needed
    - Chl a (SeaWIFS time series)
    - Zooplankton and/or other pelagic taxa data (no CalCOFI data here during 2000-2005)
- Pre-processing of data layers and analysis
    - All static snapshot data layers have been rasterized and clipped to the same spatial extent – lose some of the fine scale variation but ok because we are working on a large area and the remote sensing data are at a fairly coarse resolution. We may play with this and see if we get differences in different scales
    - EOF of SST begun

To do during this meeting
- Bring the results of EOF into ArcGIS
- Run PCA on all data layers
- Run cluster analysis
- Examine how changing which data layers are included influences results
- Examine how these results compare to other biogeographic and biophysical studies of the area (e.g. PISCO, N/Cen CA biogeographic assessment etc.)

To do after this meeting
- Add other data (e.g. Chl a SeaWIFS data)
- Run EOF on SeaWIFS data
- Try analysis at a different spatial scale (up or down sample the grids)
- Run similar analysis for human activities within the region? (e.g., Jorge Brenner et al 2006. Environmental Management – classified the land part of the coastal zone in Catalan based on human communities)

Discussion
One arbitrarily draws certain components of the ecosystem to include in the analysis – therefore the result is always driven by the data. We can ask how things vary using a subset of the variables, for example the specific ecosystem components that were identified as being strongly linked to service delivery in the regression analysis. But first, we would like to know as objectively as possible how the ecosystem varies before the management exercises.

Another interesting issue to explore is what happens if you choose different scales – within a larger scale can you define smaller scales? Especially for management can you take actions at one scale and then try to scale them up, etc.?

Having done this on a broader scale for defining management units, it will be interesting to then delve down into finer scale and then start to make linkages from the management units to services.

Would be interesting to see if human activities relate to the natural system boundaries – question is which activities. Difficult to obtain spatially explicit data for many of the activities (but see Ecotrust data).

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Presentations – Subgroup Updates Continued

Threats Analysis – Ben Halpern

Building off of global threats analysis, Ben, Fio, Carrie and Kim Selkoe were funded by the Moore Foundation to examine threats to the California Current from Washington-BC border down to Baja.

Mapping threats and marine ecosystems of the region
- 6 subregions – WA, OR, N CA, C CA, S CA, Baja (maybe split into 2 subregions)
- Central CA subregion overlaps with Monterey Bay National Marine Sanctuary

Expert opinion survey to be used with scientists, agency and NGO experts, stakeholders and other holders of traditional ecological knowledge to assess relative vulnerability of different ecosystems to different threats.

Will produce a spatial map of a distribution of the threats and the relative impacts, which allows one to compare across threats; survey asks experts in a particular ecosystem type to rank the relative vulnerability to those threats along 5 different axes with a certainty measurement; this number is used to modify the level of the threat in a pixel if the habitat is there; can use different metrics about how to set certain management actions decreases the level of threats using averages, variability, in hotspots – systematic way of prioritizing the issues and looking at how different interventions change this picture.

Will be convening a workshop with decision theory experts to evaluate the survey, adapt it for eliciting expert opinion from diverse stakeholders and consider how the results of the survey can be used in decisionmaking.

- Have been talking with sanctuary managers (Bill Douros, Andrew DeVogeleare, Jennifer Brown), and they are interested in the threats analysis
- Specific comments about things they would like to see
    - Importance of specific locations for protection based on distribution of threats
    - They are doing similar analysis of the pressures on the sanctuary, both human and natural – interested in the interaction between some of those (e.g. ENSO interaction with changes in human land use)
    - Can we add a way to incorporate the effects of environmental forcing?
    - Using analysis to look at different policy options for the sanctuary (e.g., zoning schemes, water quality treatment plans, etc.); prioritization of different management interventions and combinations of projects
- Fio to take the lead on examining different policy interventions, performance assessment, decision-making, etc.

Staffing: The grant provides for a GIS technician, 2 interns working on the expert surveys, and a postdoc (Caitlin Crane) working with TNC (Mike Beck)/UCSC (Mark Carr) looking at interactions of multiple human activities and natural impacts.

Discussion

- How to deal with nested scales? Fully independent? If some regions are more data rich than others, how do we compare across subregions?
- Important to remember that results are necessarily uncertain and will need to be updated as new information comes in.
- Potential problems with expert elicitation. Depends on the number of experts that you have (Roger Cooke at RFF is an expert at expert elicitation & using expert surveys) – pretest your experts using statistical methods so that you can compare the threats (you can identify the threats but the relative-ness of threats may require this kind of careful choice of experts)
- Could potentially be linked to cost-benefit analysis to assess which threats should be addressed.
- Does scale of threats match scale of boundaries identified in boundary delineation? Related to idea of mapping ecosystem services?
- GLOBEC database for NE Pacific for climate change data
- Historical changes and potential future changes are difficult to capture. Some historical threats are no longer threatening because they already did their damage; distribution and effects of future threats are hard to predict (invasives, global change). Focusing on current threats.
- Working with TNC and MLPA Initiative to get data.
- Data acquisition for this analysis will possibly overlap with the other models, but the spatial resolution may be coarser.
- Using the analysis to test policy and management schemes within the MBNMS and prioritize different interventions - Fio; maybe hook up with Hugh Possingham using MARZONE to look at potential alternatives for zoning of human uses and threat mitigation.

Economic Valuation and EBM – Susanne Menzel

Part I – Conceptual

- Manuscript prepared which Susanne will circulate to the group
    - Focuses on economic valuation and its combination with ecological models to support EBM
    - Plan to send to the "Concepts & Questions" section of Frontiers in Ecology and the Environment
    - Overview of current economic valuation approaches, recent developments, what is lacking if we're to apply valuation to EBM decisionmaking, and what the new approach combines

Main Results – new definitions for *degradation* and *ecosystem quality*

- Degradation: by human activity caused changed state of an ecosystem which provides conditions less beneficial for human activities than before the impact
- Meaning is not necessarily univocal
- Ecosystem Quality: configuration of an ecosystem regarding its actual capacity to contribute to the fulfillment of human needs
- Several human needs represented by different user groups and it is difficult to place them in a hierarchy
- One option is to define a high quality state of an ecosystem as one that provides favorable conditions to user groups with activities that are highly sensitive to the configuration of the ecological elements
- This is different from the body of literature on ecosystem health because placed in the context of human preference and anthropocentric
- Risky from the point of view of an ecologist – if we focus on the group that obtains the highest benefit, this may be a highly beneficial activity but it could also be related to a high threat and therefore non-sustainable
- A social contract model may solve this problem – look for a solution that results in the greatest good for the greatest number of people, i.e. find a combination of intensities of activities in a region which is overall beneficial for or will support needs of the group of people in which we are interested

Discussion

- Concerns about time frame
    - Quality that currently provides conditions or maintains capacity?
    - If focus on current activities, may ignore sustainability and potential future activities
    - Modify definition to say "maintains capacity to provide conditions…"
- Weakest link
    - Only in a high quality state if the "weakest link" is satisfied – the group that is most sensitive to changes in the ecosystem configuration (the polar bear user group)
    - Problematic if other users don't depend on the same set of conditions as the weakest link (is the weakest link a good umbrella?)
    - Another option to define high quality as the combination of activities that maximizes the benefit to society
- Sustainability
    - A potential measure that takes into account ecosystem quality for all the different user groups
- Welfare theory / ecosystem health
    - Can you bring economic perspective to ecosystem health literature?
    - Does valuation have anything to add to the ecosystem health/indicator approach?
    - Might be useful addition to manuscript

Part II – Empirical Case Study

- Kelp forest ecosystem, key human activities: recreational fishing, commercial fishing, and recreational SCUBA diving
- Aim: identify to what extent differences in yields/activity levels are attributable to ecosystem configuration (composition of the ecological elements)
- How should we combine the intensities of different activities to maximize the benefits that derive from use of a certain area? Or how would a change in ecosystem quality affect the benefits that derive from these 3 activities?
- Activity level = f(ecosystem config, manmade features, distribution of humans)
- Assume fixed prices for each activity and use the intensity of activity as a proxy for the benefits human beings receive from engaging in the activity at particular places. Normalized by population (if you are in multiple places).
- Ecosystem configuration should include the human elements of the ecosystem.
- Measured activity levels for recreational activities in hours; extractive activities in dollars
- Derive demand curves for recreational activities as a function of ecosystem configuration if configuration is a significant explanatory variable for activity level or yield (for extractive activities); e.g. dived hours at a site would be regressed on kelp cover, fish abundance, manmade features (hours to place) – to examine explanatory power of each of these
- Expected result: "Total" economic value (total hours x benefits per hour) of each recreational activity given ecosystem configuration
- Then you can ask: If you change the ecological dimension – what happens to the activity levels?
- Time component is a big issue (ignores anything that isn't current)

Challenge

- Want all activities in one objective function
- Recreational – assumed fixed prices; expected benefits reflected in activity levels
- Commercial
    - Effort reflects costs
    - Dependent on level of technology
    - Effort/prices cannot be assumed as fixed
    - High effort can be a direct signal for low ecological quality level
- Hours cannot be the common currency; it has to be $$
- For diving
    - Can get prices from the diving survey's reported trip costs, travel costs (time) + equipment
    - How to count hours of a diving trip?
        - Shore dives – count hours in water
        - Boat dives – hours on boat+water
- Recreational fishing
    - Direct expenditures by marine angler (weight for CA) divided by total hours spent fishing.
    - Steinback et al. 2004 + data mining
        - Direct expenditures by marine anglers, weighted for CA, divided by total hours spent fishing gives you the monetary benefit of one hour of fishing.

        - This value can then be multiplied by the number of hours spent fishing in kelp to get the monetary benefit of recreational kelp forest fishing in CA.
- Commercial fishing
    - Carrie Pomeroy has looked at indirect effects of commercial fishing for central California
    - Need to track down effort and landings value data for kelp forest species

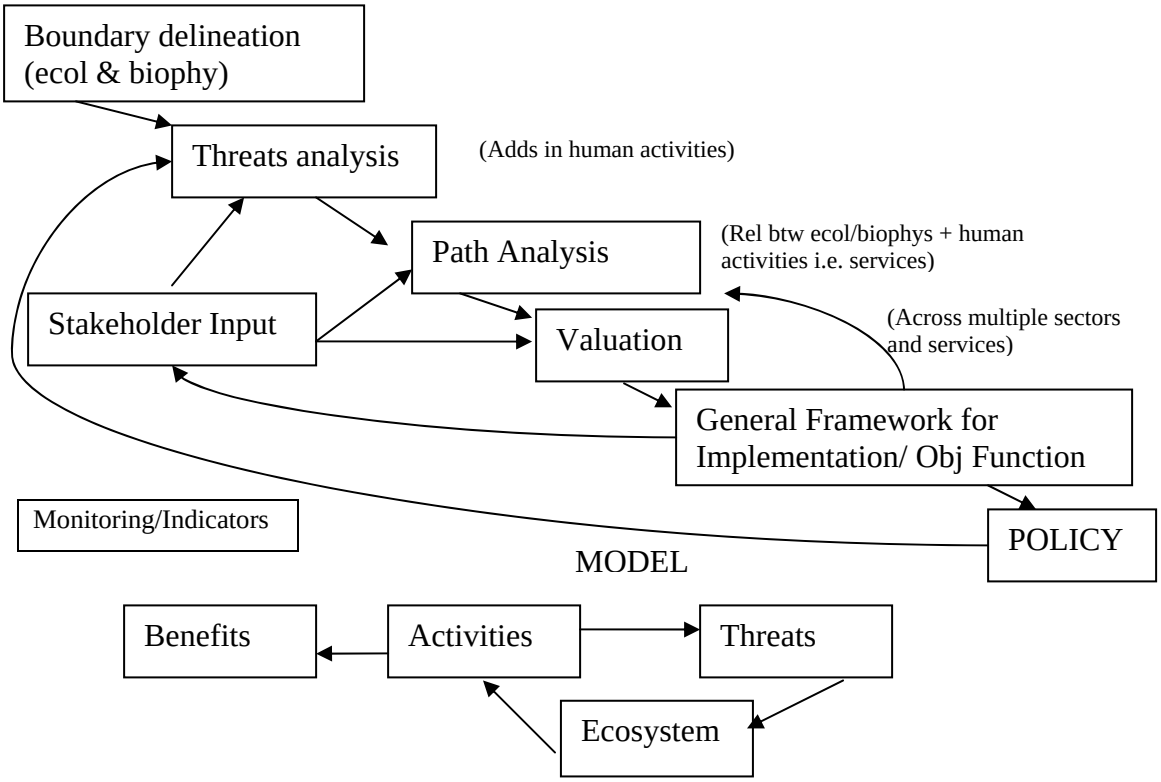
Things to be done during the meeting
- Data mining commercial fishing
    - effort
    - value of landings
- Recreational Fishing – hours spent (both as spatially explicit as possible)

After the meeting
- Finish dive survey – Sarah Teck hired to conduct the final round of interviews
- Analysis to identify drivers that generate the services that support the activities
- Develop a way to simulate the direct and indirect impacts of the human activities back on ecological elements; need set of fitted models for the ecological components that feed into the different activities (i.e. the services)
- Simulation of different management scenarios in terms of benefits in different sectors and expected benefits in next "round" (as result of feedback of ecological configuration change on benefits)

Discussion
- Still thinking about 2 scales – Monterey Bay and Central CA/S CA – but concerned about data mining capacity. It may not be possible to obtain the data we need for the entire coast but it would be nice. Need to go outside of the Monterey Bay in order to get sufficient variation in ecosystem quality – need 4 regions (Monterey, Santa Barbara/Ventura, LA, San Diego) in one analysis.
- How to deal with supporting or regulating services?
- How to deal with nonlinearities in provision of services? E.g. threshold behaviors
- Competing interests may not buy into a common optimization framework b/c they view their interests as incommensurate.
- Strict optimization may not be possible; may yield weaker guidance – satisficing solution rather optimal solution
- How do we deal with non-linearities in the provisioning of services? E.g. mangrove or wetland providing shoreline protection
    - Need to first ask the relationships for each variable or pairs of variables – e.g. relationship between canopy cover and fish abundance is not linear
    - How do you do this with multivariate relationships and multiple activities? Transform the variables so that any sort of relationship (e.g. quadratic) is possible. In path analysis, one relates the variables in linear models but the variables can be any transformation that you like

Work plan discussion

- Possible integrative EBM analysis (e.g. boundary delineation for the ecosystem, then threats analysis, do Path Analysis to get key interaction terms, do valuation analysis (stakeholder input?) and work into the general framework that Mike described with dynamical feedbacks between valuation and general framework)
- Need to think about decision analysis; in the general analysis recognition that a strict optimization may not be possible and there may be a satisficing solution rather than an optimal solution (Jim, Chris, Dave dynamic programming is the gold standard but the problem may be too complicated)
- Communicating results to allow buy-in from stakeholders and policy makers (education, outreach, adaptive management) for implementation
- A potential framework for EBM planning and implementation (Andy to start outlining a paper on this):



Work Sessions
1. Threats/path analysis: Fio, Andy, Irit, Ben, Dan, Susanne, Sarah
2. Boundary delineation: Carrie, Bernardo, Becca, Geoff

Reports from Work Sessions

Ecosystem Boundary Delineation Subgroup

Work Plan

PCAs and Cluster Analysis
1. Physical data
- SST (EOF from Bernardo)
- Bathymetry
- Geomorphological habitat types, soft/hard habitats, benthic rugosity
- Latitude
- Proximity to freshwater outflow
- Wave exposure (fetch data)
- Upwelling vs. retention zones
- Sedimentation/turbidity

2. Biological data
- Chl a (EOF), kelp persistence, kelp union
- Fish diversity, fish density, fish assemblage clusters
- Seabird diversity, seabird density, seabird counts (in colonies)
- Sea otter counts
- Pinniped counts (at haulouts)

3. Combined biophysical

Repeat for:
- Pt. Arena to Pt. Sal at 9km resolution
- Within subregions at same resolution (extent = Monterey Bay and/or other subregions identified in larger extent analysis, grain 9km)
- Within subregion at finer scale (extent= Monterey Bay or subregions identified above, grain 4km)
- Within nearshore zone, (extent = Pt. Arena to Pt. Sal, grain: < 4km)
- Within all kelp beds or shallow habitats from Pt. Arena to Pt. Sal, using the beds as the replicate sites, rather than individual pixels

Overlays/correlations with PCA results
- Corals/sponges presence
- Pinnacles
- Squid CPUE
- Spot Prawn CPUE
- CPFV CPUE
- PISCO data- inter and subtidal
- Subtidal PISCO communities cluster analysis (Carol Blanchette & Bernardo & Mark Carr)
- TOPP data?

Missing data to try to get
- Pelagics, esp. squid, zooplankton, anchovy/sardines, tunas, sharks, large pelagics
- Wave exposure, freshwater runoff, sedimentation, 1km AVHRR (SST)

Pre-processing and analytical steps (to be done in ArcGIS)
1. All files in same projection
2. All files clipped to same spatial extent
3. If data are already continuous over the entire study area, rasterize (grid format)
4. If discontinuous, interpolate if appropriate. If not appropriate, do not use in PCA.
5. Create multigrid stack of data
6. Run PCA to reduce number of variables
7. Run cluster analysis to identify areas of biophysical similarity
8. Display on map

Discussion
Larry Jacobsen may be a source for sardine/anchovy data

Threats, Path Analysis and Valuation Subgroups

Connections between threat, path analysis and valuation
- Threats focuses on potential negative impacts of human activities, but no direct description of the feedback of activities on specific ecosystem components
- Path analysis will look at interactions among different activities and also will link activities to specific changes in ecosystems
- Valuation captures the benefits of activities (to complement the threat analysis focus on negative impacts)

Data issues
- Mismatches between temporal and spatial scale and replication of the data for the threats vs. the path analysis
- For path analysis, several options:
    - Scale down scope of analysis, e.g. focus on specific aspects, such as link between activities and biophysical data (e.g. trawl survey data and catch data).
    - Wait for output from boundary delineation and threat analysis projects and go back to redrawing path analysis interaction web after you have results from those.
        - From threats analysis, describe potential negative impacts at multiple spatial scales.
        - Map activities within boundaries that come out of boundary delineation to see which activities are important within which subregions.
        - Path analysis would explore connections among activities and ecosystem components to look for strong interactions that should be included in the ultimate model that's used to inform management.
    - Move path analysis further down the process chain to be included in the general framework, rather than after threats analysis

    - Could use Susanne's path diagram as a case study and starting point and look for data to go ahead and start on that (since we've already done a mini-threat analysis for this case study, based on literature review and expert opinion)
- Threats may not match activities exactly because of the way they've been defined

Data Needs
- Determine which datasets are important for the linkages between activities and ecosystem components
- Get the data and process them into a workable format
- Post CRFS spatial data on portal – logbook data
- Get commercial logbook data if possible (Chato was working on this)
- Number of fishing hours / area for recreational fishing
- Catch for commercial fishing

Decision-making Under Uncertainty Subgroup – Chris Costello

Directing effort away from the broad perspective on EBM as economic decision-making problem

Focusing instead on the specialized set of tools that economics can offer for decision-making under uncertainty, when there is learning involved
- Uncertainty associated with scientific aspects of system (e.g. species interactions), social aspects (e.g. future valuation)
- May be aspects of the system that are not valued, but which have option value
- We know how to solve decision problems under uncertainty. But in late 1970s, there were a couple of economists who added an innovation:
    - If you acknowledge that some of the uncertainty will be resolved in the future, it should affect your decisions today, because you will have different returns on your objective function taking this into account vs. not; this wedge = *option value*
    - Not just conceptual, precautionary approach
    - An actual set of tools for calculating how much more cautious you should be, when you should be cautious, etc.
- Propose to bring this concept and the associated tools to EBM
    - Differences in biological dynamics (e.g. turnover rates of species, time required for rebuilding stock) imply differences in option value and the amount of caution an objective function should encompass
    - Irreversibility cost of making a particular decision (or associated sunk costs)
    - What's the cost of waiting longer to rebuild a resource?
    - Related to EBM concept of maintaining the capacity to produce a full suite of ecosystem services
    - Can take into account shifts in preference
    - Challenge is to constrain the examples within the EBM problem

Why would you want to bring this into the EBM context?
- EBM states that we want to maintain the capacity to produce a suite of ecosystem services

- EBM also asks "What are the dominant services?" Risk: sustainability, EBM; the dominant services now may not be telling you what you should be doing later

Discussion

- Does this rely on consequences that are irreversible or is this based on changed preferences? If there isn't a huge irreversibility cost but the preferences changed – you get lower costs.
- Relationship to appropriate discount rate?
    - Choice of discount rate affects what you do today whether or not you consider option value. Interesting to consider whether there's an interaction between the two.
- Previously working on what's the added value of EBM
    - Related to that b/c you're asking what the cost is to precluding/ignoring future options.
    - Plan to do this throughout the paper with a two species model, where you illustrate option values through the different species interactions. Shutting off interaction term will reduce it to single species model with option value.
- Scientific uncertainty also gets an option value, not just the values
    - Helps to address the criticism of EBM that you can't do it unless you know everything about the system. Let's you modify your decision now, knowing that your information will improve in the future.
    - Puts some bounds on how the precautionary principle is enacted.
- Merge vulnerability of systems with how costly it is to use the systems today?
    - With a choice between two options today (which you place different values on) and uncertainty about the future, if you incorporate option value, you have a two stage decision problem.
    - Want to make decisions today that don't preclude future options.
    - Option value greater for species that are more vulnerable (e.g. with longer recovery times)
- Bayesian approach used to parameterize probability function that describes option value
    - Pre-posterior distribution is the suite of distributions that you forecast might result from different things that you might learn
- Can you do this for multiple sectors or services? What's the interaction between the multiple decisions that you have to make today, which both have option value? Current versus future tradeoffs? Could be critical link to EBM.
- EBM principles
    - Incorporate uncertainty into current valuation
    - Assess different actions that may have tradeoffs currently and how the future benefits should be incorporated into those decisions
- Information gap theory might also be useful here
    - Method for dealing with extreme uncertainty – making decisions to minimize maximum regret or maximizing windfall profits
    - Comes from engineering
    - Has to do with objective function itself, which in economics is traditionally focused on maximizing expected value, versus the engineering loss function

approach of “minimizing maximum regret” or “maximizing potential windfall profit”

- Data limitation around species interactions is really common, so something like this could be very useful for EBM.
    - Calculate option value relative to the uncertainty around the nature of the species interaction
    - Only get option value if you also have uncertainty and irreversibility
    - Option value requires learning
    - Anything you might value in the future can be subject to option value

Timeline

- Good draft by June
- Could use some EBM decision-making “stories” to make it real
    - Rockfish rebuilding programs projected out 100 years into future
    - Deep sea corals and link to fish production

January 29

Wrap up and Final Reports from Subgroups

Andy sent around an outline on a general paper on the process of doing EBM

- Should provide an overview of the process as a whole that draws from each of the steps without geting into the details;
- Point is to highlight the connections and the sequences
- Each of the sections will then become developed on their own
- But this could easily be a boring paper…
- Core set of ideas, illustrating using examples and show where there are gaps and how to solve these problems.
- Contribution is less on detailed analyses then in laying out a path for people to follow – understanding that there will be some specifics.
- Specifying the objectives is a huge part of this and that this will vary on a local level. We can't tell a manager what to do but how to fit their objectives into this framework and then where they can go from there.
- Need a way to bring in different viewpoints from different sectors that would affect what you do using weightings. Maybe using probability distributions about human values and preferences?
- This will take a lot of effort to make it useful but not too long.
- Synthetic paper you want to be able to refer to the more detailed papers and highlight and extract the main points, both strategic and procedural from them (merits in taking the quantitative approach)
- Everyone should go into the outline and state "From the piece that I've been working on – this is our approach, these are the other types of approaches that we aren't taking, here's how this fits in, etc."
- We start from the starting premise that we should be moving towards EBM.
- We are not necessarily defining EBM, but trying to provide a generalized approach to EBM. Knowing that while indeed there are specific case studies and not all EBM approaches will be the same, we now have a tool that allows us to do EBM. Why do we need a generalized approach and why do we take an interdisciplinary approach? Single species, single sector management has failed.
- Make sure that we do this succinctly and in a general way!

How might we utilize different vehicles of communication to get this information out?

- Peer Reviewed Journals: Marine Policy, Env Management, Ecol Apps
- Alternative products that can be targeting managers
- There may be some money in the budget for report publication or brochures orr web materials.
- Presentations/Workshops – SAC, MBNMS (ask them for this)
- (e.g. NERRS Coastal Training Program)
- Also NCEAS' Kepler ecoinformatics tool – for hands on demonstration of our process and flow
- Outreach activities for the EBM module within NCEAS?

- NCEAS has strong connections to COMPASS but no specific plans on how to capitalize on this but they are interested in projects with traction and are diving into the policy side of things (e.g. New England, California). Hired someone in DC to do education/outreach in Congress but maybe also to agency folks.

System Model(s)
- Other than the simple two species models that Jim, Chris and Dave are planning to use to illustrate their paper and the exploratory path analysis models, we don't currently have a system model under development. Is this a problem? Creative ways to solve it?
- Another NCEAS working group (Dan Doak, Jim Estes et al) has been using ECOPATH to build a kelp forest model. They might be interested in collaborating with us on incorporating human uses into their network model.
- Carrie and Ben will contact Tim Tinker, Jim and Dan to see what their approach entails and if they'd be willing to collaborate.
- Mike's take: the world doesn't need another ECOPATH model – what we should focus on are the principles
- OK to do this for data poor systems and still highlight where the gaps are. This also fits in well with the option value idea.

Plan for Susanne's Empirical Study for the Kelp Forest
- Initial analysis on the Monterey Bay and possibly Channel Islands
- Statistical relationships between ecosystem variables and the activities
- Relationship between kelp canopy cover and the other variables within the PISCO dataset so that we can interpolate for those sites where we don't have community surveys.

Boundary Analysis
- Clipping data layers using the layer with the smallest offshore extent (the NMFS trawl surveys)
- Feel that though we will lose some data, we cannot extrapolate beyond the length of the trawl surveys off the slope.

Other data acquisition
- Carrie will call Rick Starr to see what kind of time series data for the Monterey Bay are available (as shown in the Status of Fishery Resources and Fisheries report)

Upcoming Meetings

Next working group meeting
- June 18-21 Working group meeting 4