

Identifying Ecosystem Boundaries

Carrie Kappel, Mike Fogarty, Rebecca Martone

Ecosystem based management is fundamentally place-based management. It begins with the goal of managing and protecting a particular ecosystem. Therefore, one of the first steps in implementing ecosystem-based management is to define the ecosystem of interest by outlining its boundaries. However, geographical boundaries of ecosystems depend on the scale considered and may also be variable in time, shifting seasonally or under changing climatic conditions. In order to define ecosystem boundaries for the purposes of management, one must decide on the scale(s) of interest, and then determine the biophysical (and in some cases socioeconomic) characteristics of ecosystems and their natural variability, recognizing that any defined system is necessarily nested within larger scale ecosystems and processes and contains smaller scale ecosystems and processes.

Approach

We tentatively plan to use nearshore coastal Central California as a case study to develop approaches to define ecosystem boundaries and address some of the cross-cutting issues in EBM, such as spatial scales of processes and management, integration of datasets collected at varying spatiotemporal scales, and coping with uncertainty in data. We recognize that the nearshore environment and the Central Coast region are both nested within larger systems and to a large degree are open to inputs and processes that will cross the boundaries we specify as potential management units. For some applications, it will be necessary to account explicitly for these “open” boundaries. During the boundary delineation exercise we will consider the implications of processes occurring at larger spatial scales and will examine the sensitivity of our results to alternative definitions of the spatial extent of the analysis. This case study was deemed appropriate because of its nested spatial scales, the quality of data available, existing interest in EBM within this area and from the agencies with jurisdiction. We have been gathering existing empirical data on this potential case study and will meet with managers from the areas to solicit their expertise and advice on key management objectives, target ecosystem services, and critical ecosystem linkages for their system.

Example questions we hope to address:

- How should the boundaries of ecosystems be defined? What constitute coherent, natural units for management within Central California?
- What are the best techniques for integrating datasets that derive from diverse disciplines and have been collected at varying resolutions and spatial scales? How can one account for the joint uncertainties associated with integrated data layers and incorporate them into models?
- How can we incorporate temporal variability and how does this variability affect the definition of boundaries? Does this differ at different scales?
- How can boundary definition be addressed in systems with less data? Can we use this technique to help prioritize data collection at different scales?

Using a GIS framework integrated with multivariate statistical approaches, we will provide a framework for managers to approach ecosystem boundary definition. Below is a step-by-step outline of our process:

- Compile physical and biological data layers and accompanying metadata for the State of California (see *Data layers for EBM boundary delineation.xls*)
- Import data layers into ArcGIS
- Decide on the scale of resolution for the analysis (e.g. 1.25 km grid) based on the datasets
- Interpolate point data (using kriging or other geospatial tool) to create raster layers
- Perform PCA on raster data to reduce variables
- Perform cluster analysis on eigenvectors from the PCA

Example analyses:

1. Test how using this model with limited data will affect boundaries. Which data layers tend to drive variation among cluster outputs?
2. Test how ratcheting the uncertainty up or down will affect our ability to define boundaries.
3. Test how temporal variability (e.g seasonal or annual changes in kelp cover or fish diversity) affects boundary delineation using maps of temporal variance.
4. Test uncertainty and data inclusion at different scales.

Questions for the group:

1. What spatial resolution would be most appropriate?
2. Are there existing analyses similar to this that we should know about?
3. Are there other data layers that should be included?
4. Are there novel questions that we could answer using this approach that we have not considered yet?

Data category	Data layer	Source	Coverage	Spatial resolution	Temporal resolution	Continuous or categorical	In hand?
Bathymetry	Bathymetry	http://marinemap.org/mlpa/viewer.htm	statewide	10 m contour intervals			Y
Substrate & Habitat type	Benthic rugosity 200m	http://marinemap.org/mlpa/viewer.htm	statewide	200 m grid	-		Y
	Benthic rugosity 5m	http://marinemap.org/mlpa/viewer.htm	Central California (MLPA Central Coast study region)	5 m grid	-	Cat: low, med, high	Y
	Seafloor type (soft vs. hard bottom)	http://marinemap.org/mlpa/viewer.htm	statewide			Cat: soft, hard	Y
	Coarse scale habitat type (also avail. intersected with MLPA depth zones and canyons)	http://marinemap.org/mlpa/viewer.htm	Central California (MLPA Central Coast study region)	?	-	Cat: multiple habitat types	Y
	Fine scale habitat type (also avail. intersected with MLPA depth zones and canyons)	http://marinemap.org/mlpa/viewer.htm	Central California (MLPA Central Coast study region)	1:5000 scale	-	Cat: multiple habitat types	Y
Kelp	Southern California Rocky Substrate	http://marinemap.org/mlpa/viewer.htm	Southern California	1:125000	-	Cat: rock	Y
	Southern California Sediment	http://marinemap.org/mlpa/viewer.htm	Southern California	1:125000	-	Cat: sediment	Y
	Kelp coverage	http://marinemap.org/mlpa/viewer.htm	statewide		1989, 1999, 2002-2004		Y
	Persistent kelp	http://marinemap.org/mlpa/viewer.htm	statewide		3 out of 4 of: 1989, 1999, 2002, 2003		Y
	Kelp abundance	SBCLTER	9 reef sites on mainland coast of SB Channel and 2 sites on N side of Santa Cruz Is.	point data (transects and quadrats)	2000-2005	Cont: number of fronds, holdfast diameter	Y
Fish and benthos	Fish diversity and abundance (spatial subset of data from NMFS trawl surveys, from N-Central CA biogeographic analysis, all years in one layer)	http://marinemap.org/mlpa/viewer.htm	Point Arena to Point Sal	point data (from trawls)	summer-fall (1977-2001)	Cont	Y
	Commercial fish landings (sp. Specific)	http://www.pfeg.noaa.gov/products/las.html	Statewide by Port	Regional (by port)	1928-2003, monthly/annual	Cont	
	Sea urchin fishery landings	http://www.dfg.ca.gov/Mrd/seaurchin/index.html	Southern California	Fishing location/Diver by Region (N & S)	1991-2003 annual	Cont (CPUE & value)	
	Commercial fish landings (sp. Specific)	http://www.dfg.ca.gov/Mrd/fishing.html	Statewide by Port	Regional (by port)	2001-2004 monthly	Cont (CPUE & value)	
	Sessile spp percent cover UPC	SBCLTER	9 reef sites on mainland coast of SB Channel and 2 sites on N side of Santa Cruz Is.	point data (transects and quadrats)	2000-2005	Cont: % cover UPC, species and/or fxn grps and substrate	Y
	Sessile spp percent cover UPC	PISCO	Central California (Santa Cruz (Sandhill) to Oxnard (Naples) plus the Channel Islands (to SBI)	point data (transects and quadrats)	1999-2005	Cont: % cover UPC, species and/or fxn grps and substrate	Y (need to download) Summary (Not in GIS layers)
	Sessile spp percent cover UPC	CRANE	88 sites from Santa Cruz to San Diego (including Channel Islands)	point data (transects and quadrats)		Cont: % cover UPC, species and/or fxn grps and substrate	2004
	Invert and algal density swaths	SBCLTER	9 reef sites on mainland coast of SB Channel and 2 sites on N side of Santa Cruz Is.	point data (transects and quadrats)	2000-2005	Cont: counts by spp	Y
	Invert and algal density swaths	PISCO	Central California (Santa Cruz (Sandhill) to Oxnard (Naples) plus the Channel Islands (to SBI)	point data (transects and quadrats)	1999-2005	Cont: counts by spp	Y (need to download) Summary (Not in GIS layers)
	Invert and algal density swaths		88 sites from Santa Cruz to San Diego (including Channel Islands)	point data (transects and quadrats)		Cont: counts by spp	2004
	Fish abundance	SBCLTER	9 reef sites on mainland coast of SB Channel and 2 sites on N side of Santa Cruz Is.	point data (40 x 2 m swath transects, midwater and benthic)	2000-2006	Cont: counts by spp and length of each indiv	Y
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	Fish abundance	CRANE	88 sites from Santa Cruz to San Diego (including Channel Islands)	point data (40 x 2 m swath transects, midwater and benthic)		Cont: counts by spp and length of each indiv	2004

Data category	Data layer	Source	Coverage	Spatial resolution	Temporal resolution	Continuous or categorical	In hand?
Seabirds	Bird density	http://marinemap.org/mlpa/viewer.htm	Northern and Central California	5' grid	1975-1997 (avail divided into warm, cold, and neutral water periods or Davidson Current Season vs. Oceanic Season vs. Upwelling Season)	cont: 76 species	Y
	Bird diversity	http://marinemap.org/mlpa/viewer.htm	Northern and Central California	5' grid	1975-1997 (avail divided into warm, cold, and neutral water periods or Davidson Current Season vs. Oceanic Season vs. Upwelling Season)	cont: Shannon-Wiener Index	Y
Marine mammals	Bird biomass density	http://marinemap.org/mlpa/viewer.htm	Northern and Central California	5' grid	1984, 2001 (avail divided into warm, cold, and neutral water periods or Davidson Current Season vs. Oceanic Season vs. Upwelling Season)	cont: 76 spp, kg/km2	Y
	Bird breeding colonies	http://marinemap.org/mlpa/viewer.htm	Northern and Central California	point data	1980, 2000, updated w/ 2002		Y
	Bird colonies with counts by species (MMS survey)	http://seamap.env.duke.edu/datasets/detail/271	statewide	point data		cont: counts by species or 1980 presence/absence	Y
	Marine mammal haulouts	http://marinemap.org/mlpa/viewer.htm	statewide	point data		2002	Y
	Marine mammal rookeries	http://marinemap.org/mlpa/viewer.htm	statewide	point data		2002	Y
	Marine mammal counts	http://seamap.env.duke.edu/datasets/detail/271	statewide	point data		1991 cont: counts by species	Y
	Sea otter counts	http://marinemap.org/mlpa/viewer.htm	Golden Gate to Santa Barbara	0.5 km intervals	2001, 2002	Cont: counts	Y
Zooplankton	sea otter linear densities	http://marinemap.org/mlpa/viewer.htm	Golden Gate to Santa Barbara	10 km segments	2001-2002	Cat: low, med, high	Y
			CalCOFI cruise locations and interpolated data, statewide in earlier years, Southern California in more recent years	point data	1951-1998, at least quarterly		
Temperature	Zooplankton biomass	CalCOFI	CalCOFI cruise locations and interpolated data, statewide in earlier years, Southern California in more recent years	point data	1951-1998, at least quarterly		
	Temperature	CalCOFI	CalCOFI cruise locations and interpolated data, statewide in earlier years, Southern California in more recent years	point data	1949-2005, at least quarterly		
	Temperature	SBCLTER	24 grid stations and 7 trans-channel stations in Santa Barbara Channel and around Channel Islands	point data	2001-2003 (have 2003 data only)	Cont	Y
	SST	AVHRR http://las.pfeg.noaa.gov/oceanWatch/ocean	statewide	1.25 km	1,3,8,14 day composites from 2006, archives elsewhere	Cont	N Y (need to download)
Salinity	Ocean temperature	SeaWIFS	statewide	0.1 degree	monthly or 8 day (1985-2003)	Cont	
	Salinity	CalCOFI	CalCOFI cruise locations and interpolated data, statewide in earlier years, Southern California in more recent years	point data	1949-2005, at least quarterly		
Water chemistry	Salinity	SBCLTER	24 grid stations and 7 trans-channel stations in Santa Barbara Channel and around Channel Islands	point data	2001-2003 (have 2003 data only)	Cont	Y
	Phosphate	CalCOFI	CalCOFI cruise locations and interpolated data, statewide in earlier years, Southern California in more recent years	point data	1949-2005, at least quarterly	Cont	
Primary productivity	Oxygen	CalCOFI	CalCOFI cruise locations and interpolated data, statewide in earlier years, Southern California in more recent years	point data	1949-2005, at least quarterly	Cont	
	Oceanic constituents	SBCLTER	24 grid stations and 7 trans-channel stations in Santa Barbara Channel and around Channel Islands	point data	2001-2003 (have 2003 data only)	Cont	Y
	Surface and water column NPP	SBCLTER	24 grid stations and 7 trans-channel stations in Santa Barbara Channel and around Channel Islands	point data	2001-2003 (have 2003 data only)	Cont	Y
	Chlorophyll	CalCOFI	CalCOFI cruise locations and interpolated data, statewide in earlier years, Southern California in more recent years	point data	1983-2005, at least quarterly	Cont	
Upwelling	Chlorophyll	MODIS on Aqua	statewide	1.25 km			
	Chlorophyll	SeaWIFS	statewide	0.1 degree	monthly or 8 day (1997-2005)	Cont	Y (need to download)
	Primary productivity (derived from SeaWIFS Chl a)	SeaWIFS	statewide	0.1 degree	monthly(1997-2005)	Cont	Y (need to download)
	Upwelling index	http://www.pfeg.noaa.gov/products/las.html	15 locations along California Current	point data			