LOCATING POTENTIAL RESERVES IN THE CHANNEL ISLANDS

Marine Reserves Working Group Meeting
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112 West Cabrillo Boulevard
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INTRODUCTION

Representative habitats and unique biological features in the Channel Islands were located using "Sites v. 1", an analytical tool for designing ecoregional conservation portfolios developed by Sandy Andelman, Ian Ball, Frank Davis, and David Stoms. "Sites v. 1" was developed at the National Center for Ecological Analysis and Synthesis, University of California, Santa Barbara, to meet the needs of the Nature Conservancy's Ecoregional Planning Process. The program uses simulated annealing to identify a set of sites that collectively capture examples of all habitats, features, or populations from among a larger set of "planning units" within an "ecoregion".

BIOREGIONAL REPRESENTATION

The study area (CINMS) was divided into three bioregions based on species distributions and mean sea surface temperature maps:

1. Californian Province: Anacapa, and east Santa Cruz,
2. Transition Zone: Santa Barbara, south Santa Cruz and south Santa Rosa Islands, and
3. Oregonian Province: San Miguel, north Santa Rosa, and north Santa Cruz Islands.

Each of the bioregions was divided into 1 x 1 minute "planning units" that were assigned value based on the goals and objectives (e.g. habitat diversity and species diversity).

INPUT DATA

The process of simulated annealing begins by identifying a set of input parameters. The input parameters depend on the goals and objectives for the reserve network. The Science Panel developed a list of input parameters based on the MRWG goals and objectives for "Ecosystem Biodiversity", "to protect representative and unique marine habitats, ecological processes, and populations of interest". The following input parameters were used to locate potential reserve sites in the Channel Islands region (See Appendix A for references).

1. Rocky coastline (miles)
2. Sandy coastline (miles)
3. Wave-cut coastline (miles)
4. Soft sediment (0-30 m) (square miles)
5. Hard sediment (0-30 m) (square miles)
6. Soft sediment (30-100 m) (square miles)
7. Hard sediment (30-100 m) (square miles)
8. Soft sediment (100-200 m) (square miles)
9. Hard sediment (100-200 m) (square miles)
10. Soft sediment (>200 m) (square miles)
11. Hard sediment (>200 m) (square miles)
12. Emergent Nearshore Rocks (number)
13. Emergent Offshore Rocks (square miles)
14. Submerged Rocks and Pinnacles (square miles)
15. Submarine Canyons (square miles)
16. Kelp Forest (square miles)
17. Eelgrass (square miles)
18. Surfgrass (square miles)
19. Bird Rookeries (linear miles)
20. Marine Mammal Haulouts (linear miles)

ESTABLISHING TARGETS

The area of each of these habitats and features was estimated in each planning unit. Then the "target" percentage of the area covered by each of these habitats and features was estimated within each bioregion. In different analyses, the Sites program included (in a set of potential reserve sites) 30%, 40%, and 50% of each habitat or feature in each bioregion (Appendix B).

The Sites program randomly generates an initial reserve system that includes the target percentage of each habitat and feature. The program then calculates an objective function based on the input parameters. The objective function consists of two main sections; the first is a measure of the cost of the reserve system (currently based on the boundary length of each planning unit) and the second is a penalty for violating various goals and objectives. The program evaluated 1,000,000 annealing iterations per run. At

each iteration, a planning unit is chosen at random which might or might not already be in the reserve system. The program evaluates the change to the value of the reserve system that would occur if this planning unit were added or removed from the system. At each step, the new solution is compared to the previous solution, and the best one is accepted.

The minimum set approach does not account explicitly for the spatial relationships among the sites selected for the reserve system. Without some modification or additional constraints, the final reserve system will almost always be highly fragmented and, thus, inappropriate. Fragmentation is a problem because there are both ecological and economic reasons why reserves should be spatially contiguous with low edge to area ratios. Clustering of reserve sites can be achieved by including an adjacency constraint and minimizing the boundary length of the reserve system. The boundary length modifier was set to a value of 1, which clusters planning units into discrete potential reserve sites.

The program repeated the number of runs of each analysis in proportion to the size of each bioregion. Setting the number of runs equal to the number of cells in a bioregion allowed comparison of results between bioregions. After the analysis, the program provided an array of information about each run.

OUTPUT DATA

The Sites model produces an array of output data including (1) the solutions for each run, (2) the best solution of all runs, (3) summary information about all runs, and (4) the summed solutions over all runs.

A large number of good solutions may satisfy a single set of input criteria. Each solution is given a score equal to the conservation value minus the cost (boundary length) of the reserve. The “best” solution of all runs is the scenario with the greatest conservation value and the lowest cost.

The summary details of each run include the target for each habitat or feature, whether or not the target was met, the proportion of the target met, and the actual area of the habitat or feature that was included in the best scenario. The data are grouped by biogeographic province and target percentage.

The summed solutions over all runs describes the number of times each planning unit was selected for the final scenario out the total number of runs. The summed solutions were converted to percentages by dividing the number of times each planning unit was selected for the final scenario by the total number of planning units in the bioregion (Figure 1). For example, cells that are selected in 70%, 80%, or 90% of the runs are likely to have high conservation value, whereas cells that are selected in 5% or 10% of the runs are likely to have lower conservation value.

CLUSTER ANALYSIS

Because a large number of solutions may satisfy a single set of input criteria, it is important to understand the similarities and differences among solutions. Solutions were compared using cluster analysis in Primer v. 4, a statistical program developed by the Plymouth Marine Laboratory. The 100 top ranking solutions were selected from the total runs (which varied from 314 to 786 for each bioregion). For each run, planning units were assigned a value of 1 if they were included in the final solution, or 0 if they were not. The Bray-Curtis similarity between solutions was calculated for the 100 top ranking solutions. The Primer statistical program developed a dendrogram, or hierarchical branching diagram, showing the relationships between the 100 top ranking solutions. Similar solutions were clustered together whereas dissimilar solutions were placed more distantly from each other on the dendrogram.

Clusters of solutions were divided into groups based on Bray-Curtis similarity among clusters. For most analysis, solutions with more than 60% similarity were grouped together. However, the input criteria at 30% set-aside in the Oregonian Province and the Transition Zone produced large numbers of dissimilar solutions that exhibited high conservation value. Therefore, clusters of solutions at 30% set-aside for the Oregonian Province and the Transition Zone were grouped together above 40% similarity. Grouping based on Bray-Curtis similarity produced approximately 5 groups per analysis. If the grouping algorithm produced more than 5 groups, the group with the lowest high score was removed from the analysis (Appendix C).

Solutions within each cluster were ranked according to conservation value. The top ranking solution in each cluster was selected for consideration by the MRWG (Figures 2-11). Solutions with the same rank in each bioregion were plotted on a single figure. However, analyses within each bioregion were independent of other bioregions. Therefore, it is important to remember that solutions in each bioregion should be evaluated independently.

APPENDIX A. Sources of Data

1. Sediments

A. Sediment Type

Continental Shelf Data Systems.
Division of Doeringsfeld
Almuedo and Ivey, Engineers
Denver, Colorado

Date: 1967

Description: Point data that describe the sediment type (rock, gravel, shell, sand, mud) from grab samples of the sea floor around the Channel Islands region.

B. Sediment Type

United States Geologic Survey
Coastal Marine Geology Team
345 Middlefield Road, MS 999
Menlo Park, CA 94025

Date: 2000

Description: Point data that describe the soft sediments (mud, sand, gravel) from grab samples of the sea floor around the Channel Islands. Sources of samples vary. The data were consolidated by USGS.

II. Plants

A. Kelp Forest Canopy

Ecoscan Resource Data
PO Box 1046
Freedom, CA 95019
408-728-3285

Date: 1980-1989

Description: Kelp forest surface canopy around the northern Channel Islands and Santa Barbara Island. Total coverage represents the composite or maximum distribution for kelp between 1980-1989. One layer represents the kelp forest canopy in 1989.

II. Plants

B. Eelgrass

Jack Engle
j_engle@lifesci.ucsb.edu
Marine Science Institute
University of California at Santa Barbara
Santa Barbara, CA 93106
805-893-8547

Date: 2000

Description: Unpublished hard copy maps of eelgrass beds in the Channel Islands region. To be published in December 2000 in collaboration with the Minerals Management Service.

C. Surfgrass

Bureau of Land Management
Helicopter Intertidal Survey
Hard copy maps.
Pacific OCS Office
1340 W. Sixth Street, Rm. 200
Los Angeles, CA 90017

Description: Location of surfgrass beds in the Channel Islands region. Maps were developed from helicopter surveys along the coast of the Channel Islands.

III. Marine Mammals

A. Marine Mammal Haulouts

Channel Islands National Marine Sanctuary
113 Harbor Way, Suite 150
Santa Barbara, CA 93109
805-966-7107

Date: 2000

Description: Haul-out sites for California sea lions, elephant seals, harbor seals, northern fur seals, and Stellar sea lions in the Channel Islands region.

IV. Seabirds

A. Bird Rookeries

H.R. Carter, Gerard J. McChesney, D.L. Jaques, C.S. Strong, M.W. Parker, J.E. Takekawa, D.L. Jory, and D.L. Whitworth. 1992. Breeding Populations of Seabirds in California, 1989-1991. Volume II – Colony Maps and Appendices.

US Fish and Wildlife Service
Northern Prairie Wildlife Research Center
6924 Tremont Road
Dixon, CA 95620

San Francisco Bay National Wildlife Refuge Complex
PO Box 524
Newark, CA 94560

Date: 1992.

Description: Location of breeding populations of seabirds in the Channel Islands. Data were collected for the following species: ashy storm-petrel, black oystercatcher, black storm-petrel, Brandt's cormorant, California brown pelican, Cassin's auklet, common murrelet, double-crested cormorant, Leach's storm-petrel, pelagic cormorant, pigeon guillemot, rhinocerous auklet, snowy plover, tufted puffin, western gull, and Xantus' murrelet.

B. Bird Rookeries

Ingram, T. 1990. Seabird Monitoring in the Channel Islands National Park. Channel Islands National Park Science Report. CHIS-92-001.

Ingram, T, and DJ Carter. 1997. Seabird Monitoring: Channel Islands National Park. 1991-1992. Channel Islands National Park Technical Report. CINP-TR-97-02.

Channel Islands National Park
1901 Spinnaker Drive
Ventura, CA 93001

Date: 1990-1997

Description: Location of breeding populations of seabirds in the Channel Islands. Data were collected for the following species: California brown pelican, Cassin’s auklet, double-crested cormorant, pelagic cormorant, snowy plover, western gull, and Xantus’ murrelet.

APPENDIX B. Target Values for Ecological Criteria

Table 1. Target Values for Ecological Criteria in the Californian Province.

Criteria for Reserve Site Selection	Total	30%	40%	50%
1. Rocky Coast (mi)	**12.5**	3.8	5.0	6.3
2. Sandy Coast (mi)	**4.7**	1.4	1.9	2.4
3. Wave-Cut Coast (mi)	**1.4**	0.4	0.6	0.7
4. Soft Sediment (0-30 m) (mi^2)	**16.4**	4.9	6.6	8.2
5. Hard Sediment (0-30 m) (mi^2)	**6.6**	2.0	2.6	3.3
6. Soft Sediment (30-100 m) (mi^2)	**56.2**	16.9	22.5	28.1
7. Hard Sediment (30-100 m) (mi^2)	**3.9**	1.2	1.6	2.0
8. Soft Sediment (100-200 m) (mi^2)	**27.2**	8.2	10.9	13.6
9. Hard Sediment (100-200 m) (mi^2)	**1.1**	0.3	0.4	0.5
10. Soft Sediment (>200 m) (mi^2)	**160.7**	48.2	64.3	80.4
11. Hard Sediment (>200 m) (mi^2)	**2.3**	0.7	0.9	1.1
12. Emergent Nearshore Rocks (No.)	**95.0**	28.5	38.0	47.5
13. Emergent Offshore Rocks (mi)	**1.0**	0.3	0.4	0.5
14. Submerged Rocks (mi)	**4.0**	1.2	1.6	2.0
15. Submarine Canyons (mi)	**5.0**	1.5	2.0	2.5
16. Kelp Forest (mi^2)	**1.8**	0.6	0.7	0.9
17. Eelgrass (mi^2)	**0.2**		0.1	0.1
18. Surfgrass (mi^2)	**3.2**	0.9	1.3	1.6
19. Ashy Storm-Petrel (mi)				
20. Black Oystercatcher (mi)	**25.7**	7.7	10.3	12.8
21. Black Storm-Petrel (mi)				
22. Brandt's Cormorant (mi)	**14.7**	4.4	5.9	7.3
23. California Brown Pelican (mi)	**6.2**	1.8	2.5	3.1
24. Cassin's Auklet (mi)	**4.8**	1.4	1.9	2.4
25. Common Murrelet (mi)				
26. Double-Crested Cormorant (mi)	**5.5**	1.6	2.2	2.7
27. Leach's Storm-Petrel (mi)	**2.5**	0.8	1.0	1.3
28. Pelagic Cormorant (mi)	**23.3**	7.0	9.3	11.7
29. Pigeon Guillemot (mi)	**24.8**	7.4	9.9	12.4
30. Rhinocerous Auklet (mi)				
31. Tufted Puffin (mi)				
32. Western Gull (mi)	**20.8**	6.2	8.3	10.4
33. Xantus' Murrelet (mi)	**9.6**	2.9	3.8	4.8
34. Snowy Plover (mi)				
35. California Sea Lion (mi)				
36. Elephant Seal (mi)				
37. Harbor Seal (mi)	**12.7**	3.8	5.1	6.4
38. Northern Fur Seal (mi)				
39. Stellar Sea Lion (mi)				

APPENDIX B. Target Values for Ecological Criteria

Table 2. Target Values for Ecological Criteria in the Transition Zone.

Criteria for Reserve Site Selection	**Total**	**30%**	**40%**	**50%**
1. Rocky Coast (mi)	**11.6**	3.5	4.6	5.8
2. Sandy Coast (mi)	**13.8**	4.1	5.5	6.9
3. Wave-Cut Coast (mi)	**13.6**	4.1	5.4	6.8
4. Soft Sediment (0-30 m) (mi^2)	**29.6**	8.9	11.8	14.8
5. Hard Sediment (0-30 m) (mi^2)	**7.2**	2.1	2.9	3.6
6. Soft Sediment (30-100 m) (mi^2)	**63.6**	19.1	25.4	31.8
7. Hard Sediment (30-100 m) (mi^2)	**10.1**	3.0	4.0	5.0
8. Soft Sediment (100-200 m) (mi^2)	**62.9**	18.9	25.2	31.5
9. Hard Sediment (100-200 m) (mi^2)	**7.3**	2.2	2.9	3.6
10. Soft Sediment (>200 m) (mi^2)	**176.9**	53.1	70.8	88.5
11. Hard Sediment (>200 m) (mi^2)	**14.6**	4.4	5.8	7.3
12. Emergent Nearshore Rocks (No.)	**208.0**	62.4	83.2	104.0
13. Emergent Offshore Rocks (mi)	**5.0**	1.5	2.0	2.5
14. Submerged Rocks (mi)	**27.0**	8.1	10.8	13.5
15. Submarine Canyons (mi)	**34.0**	10.2	13.6	17.0
16. Kelp Forest (mi^2)	**6.0**	1.8	2.4	3.0
17. Eelgrass (mi^2)	**0.1**			0.1
18. Surfgrass (mi^2)	**6.7**	2.0	2.7	3.4
19. Ashy Storm-Petrel (mi)				
20. Black Oystercatcher (mi)	**31.3**	9.4	12.5	15.7
21. Black Storm-Petrel (mi)	**6.3**	1.9	2.5	3.1
22. Brandt's Cormorant (mi)	**7.1**	2.1	2.8	3.6
23. California Brown Pelican (mi)	**6.3**	1.9	2.5	3.1
24. Cassin's Auklet (mi)	**9.1**	2.7	3.6	4.5
25. Common Murrelet (mi)	**6.3**	1.9	2.5	3.1
26. Double-Crested Cormorant (mi)				
27. Leach's Storm-Petrel (mi)	**6.3**	1.9	2.5	3.1
28. Pelagic Cormorant (mi)	**24.8**	7.5	9.9	12.4
29. Pigeon Guillemot (mi)	**18.7**	5.6	7.5	9.3
30. Rhinocerous Auklet (mi)				
31. Tufted Puffin (mi)	**6.3**	1.9	2.5	3.1
32. Western Gull (mi)	**16.4**	4.9	6.5	8.2
33. Xantus' Murrelet (mi)	**8.5**	2.6	3.4	4.3
34. Snowy Plover (mi)	**6.0**	1.8	2.4	3.0
35. California Sea Lion (mi)	**6.3**	1.9	2.5	3.1
36. Elephant Seal (mi)	**3.9**	1.2	1.6	1.9
37. Harbor Seal (mi)	**25.3**	7.6	10.1	12.7
38. Northern Fur Seal (mi)				
39. Stellar Sea Lion (mi)				

APPENDIX B. Target Values for Ecological Criteria

Table 3. Target Values for Ecological Criteria in the Oregonian Province.

Criteria for Reserve Site Selection	Total	30%	40%	50%
1. Rocky Coast (mi)	**28.2**	8.5	11.3	14.1
2. Sandy Coast (mi)	**25.0**	7.5	1	12.5
3. Wave-Cut Coast (mi)	**27.4**	8.2	11.0	13.7
4. Soft Sediment (0-30 m) (mi^2)	**38.9**	11.7	15.6	19.4
5. Hard Sediment (0-30 m) (mi^2)	**34.3**	10.3	13.7	17.1
6. Soft Sediment (30-100 m) (mi^2)	**211.6**	63.5	84.6	105.8
7. Hard Sediment (30-100 m) (mi^2)	**23.4**	7.0	9.4	11.7
8. Soft Sediment (100-200 m) (mi^2)	**157.0**	47.1	62.8	78.5
9. Hard Sediment (100-200 m) (mi^2)				
10. Soft Sediment (>200 m) (mi^2)	**227.0**	68.1	90.8	113.5
11. Hard Sediment (>200 m) (mi^2)				
12. Emergent Nearshore Rocks (No.)	**216.0**	64.8	86.4	108.0
13. Emergent Offshore Rocks (mi)	**12.0**	3.6	4.8	6.0
14. Submerged Rocks (mi)	**6.0**	1.8	2.4	3.0
15. Submarine Canyons (mi)	**1.0**	0.3	0.4	0.5
16. Kelp Forest (mi^2)	**16.1**	4.8	6.4	8.0
17. Eelgrass (mi^2)	**0.3**	0.1	0.1	0.2
18. Surfgrass (mi^2)	**13.4**	4.0	5.3	6.7
19. Ashy Storm-Petrel (mi)	**0.6**	0.2	0.2	0.3
20. Black Oystercatcher (mi)	**76.7**	23.0	30.7	38.3
21. Black Storm-Petrel (mi)	**0.4**	0.1	0.2	0.2
22. Brandt's Cormorant (mi)	**41.6**	12.5	16.6	20.8
23. California Brown Pelican (mi)	**0.4**	0.1	0.2	0.2
24. Cassin's Auklet (mi)	**13.3**	4.0	5.3	6.7
25. Common Murrelet (mi)	**0.4**	0.1	0.2	0.2
26. Double-Crested Cormorant (mi)	**0.4**	0.1	0.2	0.2
27. Leach's Storm-Petrel (mi)	**7.6**	2.3	3.0	3.8
28. Pelagic Cormorant (mi)	**73.0**	21.9	29.2	36.5
29. Pigeon Guillemot (mi)	**48.2**	14.5	19.3	24.1
30. Rhinocerous Auklet (mi)	**5.3**	1.6	2.1	2.7
31. Tufted Puffin (mi)	**0.4**	0.1	0.2	0.2
32. Western Gull (mi)	**53.7**	16.1	21.5	26.9
33. Xantus' Murrelet (mi)	**5.3**	1.6	2.1	2.7
34. Snowy Plover (mi)	**18.0**	5.4	7.2	9.0
35. California Sea Lion (mi)	**5.6**	1.7	2.2	2.8
36. Elephant Seal (mi)	**17.8**	5.3	7.1	8.9
37. Harbor Seal (mi)	**47.9**	14.4	19.2	24.0
38. Northern Fur Seal (mi)	**4.4**	1.3	1.8	2.2
39. Stellar Sea Lion (mi)	**3.9**	1.2	1.6	2.0

APPENDIX C.
Conservation Values and Scores of Potential Reserve Scenarios

Table 1. Conservation value and size of the top five dissimilar scenarios in the Californian Province.

Rank	Score (30%)	Size (30%)	Score (50%)	Size (50%)
1	148.51	93	211.12	155
2	146.85	92	209.08	156
3	146.76	92	207.90	153
4	142.86	100	207.65	154
5	142.83	96	203.98	158
Actual		**94.2**		**157**

Table 2. Conservation value and size of the top five dissimilar scenarios in the Transition Zone.

Rank	Score (30%)	Size (30%)	Score (50%)	Size (50%)
1	183.61	127	264.51	201
2	179.91	117	261.92	209
3	179.34	123	261.62	208
4	177.53	120	260.98	211
5	1773.5	129	253.77	206
Actual		**120.6**		**201**

Table 3. Conservation value and size of the top five dissimilar scenarios in the Oregonian Province.

Rank	Score (30%)	Size (30%)	Score (50%)	Size (50%)
1	343.30	237	508.88	393
2	334.55	236	495.56	377
3	330.03	224	493.17	371
4	327.78	234	492.44	394
5	324.00	229	489.42	364
Actual		**235.8**		**393**