CHAPTER 7 INTEGRATION

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Previous chapters examined taxon-specific patterns of abundance, distribution, and community structure, as well as, physical/oceanographic data to evaluate boundary expansion concepts being considered by CINMS. For a review of the boundary concepts see Appendix A. The intent of this chapter is to provide, where possible, a synoptic overview of these patterns. The analyses conducted within this chapter will examine the degree to which the cumulative set of prior analyses favors one concept over another. They will also depict the extent to which areas deemed important for each taxonomic group (invertebrates, fishes, birds, mammals) co-occur across the study area and which boundary concepts capture these important regions. This visual depiction of these important regions can also be utilized to suggest further concepts that warrant future consideration. Finally, the last section highlights species within this assessment listed as threatened or endangered under the Endangered Species Act and how their distributions relate to the boundary concepts.

7.1 NUMERICAL INTEGRATION

Data and Methods

The OAI (Optimal Area Index), defined in Chapter 1.4, provides a standardized set of information to assess the physical and biological environment in the context of sanctuary boundary expansion. Absolute OAI results for 48 analyses were used to rank boundary concepts in terms of ecological benefit and area gained. Only absolute OAI values were included in this integration due to their commonality across datasets. Ranks were calculated for individual analyses within 5 analytical groups: physical setting (e.g. sea surface temperature, kelp distribution), invertebrates, fishes, birds, and mammals, and for the composite of all analyses (Table 7.1.1). The final composite rank for each concept was determined by calculating the mean rank for all analyses. A standard Kruskal-Wallis rank sums test (Sokal and Rohlf, 1969) was used to determine whether mean ranks were statistically different across boundary concepts for each analytical grouping, as well as for the composite of these ranks (Table 7.1.2).

Analysis of Boundary Concepts

The Study Area boundary received the highest ranking for 56% of the individual analyses, and highest for all the taxonomic and physical setting groups, and the composite analyses. Concept 2 ranked highest for 17% of the individual analyses and ranked second, behind the Study Area, for all groups, except invertebrates. The Study Area was overwhelmingly favored for all but one of the invertebrate analyses, while more variability was observed within the other groups. Statistically significant differences were found for each of the groupings with the exception of the physical setting group. The variables in this group are a combination of dynamic and static parameters and tended to rank on the opposite ends of the expansion spectrum. For example, ocean color ranked higher in larger concepts, while substrate type and physiographic complexity ranked high in smaller concepts. When compared as a group, no difference in mean rank was observed; however, the remaining group analyses suggest that the difference in ranks is real. No significant difference was observed between the Study Area and Concept 2 for fish, birds, and mammal group rankings, but they were significantly different than the other concepts. The Study Area was statistically different than all other concepts for invertebrates and for all the data in composite (Table 7.1.2).

High rankings were predominant for concepts whose northern boundary included portions of the nearshore habitats associated with the mainland. Concepts that included portions of the mainland benefitted from the gain of complex nearshore habitats (kelp, seagrasses, rocky areas) and areas of high primary productivity that are typically associated with high species richness and diversity. Rankings increased for these concepts as their total nearshore area increased; however, this pattern was not linear. Concepts 1, 1a, and the Study Area contained the same amount of mainland coastal area, but Concepts 1 and 1a ranked behind the Study Area and Concept 2, respectively. OAI rankings tended to be lower for Concepts 1 and 1a due to large areas of deep water habitat which were less significant for the composite of species analyzed. These areas extend offshore west of Point Conception, including a portion of the Santa Lucia Bank (Figure 1.1.2). This contributed negatively to the ratio of analytical results and the increase in boundary size relative to the current CINMS boundary.

It has been well documented that the convergence of warm and cold water masses and their associated biota create a unique and diverse ecosystem around Point Conception and the CINMS. Patterns of OAI results support this and provide a good example of the physical and biological linkages within this region.

Table 7.1.1. Absolute OAI rankings for individual groups and the composite for all analyses.

		Concept						
		5	**4**	**3**	**2**	**1A**	**1**	**SA**
Physical Setting	Physiographic Complexity	1	2	5	7	3.5	3.5	6
	Benthic Substrate	1	2	3	6	4.5	4.5	7
	Bathymetric Life-Zones	7	6	5	2.5	2.5	4	1
	Ocean Color/ChlA	4	7	3	2	6	5	1
	Seagrasses	6.5	6.5	4	1	4	4	2
	Kelp	6.5	6.5	3	2	4.5	4.5	1
	Mean	4.33	5.00	3.83	3.42	4.17	4.25	3.00
	Rank	**6**	**7**	**3**	**2**	**4**	**5**	**1**
Marine Invertebrates	Brown rock crab	6.5	6.5	5	4	2.5	2.5	1
	Red rock crab	6.5	6.5	5	4	2.5	2.5	1
	Yellow rock crab	6.5	6.5	5	4	2.5	2.5	1
	Black abalone	6.5	6.5	5	2	3.5	3.5	1
	Red abalone	6.5	6.5	5	1	3.5	3.5	1
	White abalone	5	5	5	5	2.5	2.5	1
	California market squid	7	6	5	2	3.5	3.5	1
	Sheep crab	6.5	6.5	5	4	2.5	2.5	1
	Spot shrimp	1	5	4	3	6.5	6.5	2
	Ridgeback rock shrimp	7	6	3	2	4.5	4.5	1
	California spiny lobster	6.5	6.5	5	4	2.5	2.5	1
	California sea cucumber	5	7	6	2	3.5	3.5	1
	Warty sea cucumber	6.5	6.5	5	4	2.5	2.5	1
	Red sea urchin	6.5	6.5	5	4	2.5	2.5	1
	Purple sea urchin	6.5	6.5	5	4	2.5	2.5	1
	Mean	6.00	6.27	4.87	3.27	3.17	3.17	1.13
	Rank	**6**	**7**	**5**	**4**	**2.5**	**2.5**	**1**
Marine Fishes	Pacific angel shark	6	7	5	4	2.5	2.5	1
	Thresher shark (adult/juvenile)	2.5	2.5	2.5	2.5	7	6	5
	Leopard shark (adult)	6.5	6.5	5	2	3.5	3.5	1
	Tope (adult/juvenile)	1	7	4	3	5.5	5.5	2
	Cowcod (adult/juvenile)	5	1	2	3	5	5	4
	Bocaccio (adult/juvenile)	5	1	2	3	6.5	6.5	4
	Lingcod (adult/juvenile)	7	6	5	2	3.5	3.5	1
	Giant seabass	6.5	6.5	5	2	3.5	3.5	1
	California sheephead	6.5	6.5	5	2	3.5	3.5	1
	California halibut	6	7	5	4	2.5	2.5	1
	Mean	5.20	5.10	4.05	2.75	4.30	4.20	2.10
	Rank	**7**	**6**	**5**	**2**	**4**	**3**	**1**
Marine Birds	Ashy storm-petrel	7	3	1	2	5	6	4
	Black oystercatcher	6.5	6.5	5	1	3.5	3.5	2
	Brandt's cormorant	6.5	6.5	1	3	4.5	4.5	2
	Brown Pelican	5	7	4	6	2.5	2.5	1
	Cassin's auklet	7	6	5	2	3	4	1
	Double-crested cormorant	6.5	6.5	4	5	2.5	2.5	1
	California least tern	6	6	6	3.5	1.5	1.5	3.5
	Pelagic cormorant	6.5	6.5	5	1	3.5	3.5	2
	Pigeon guillemot	7	6	5	1	3.5	3.5	2
	Xantus's Murrelet	1	2	3	4	6.5	6.5	5
	Comminity/Bird diversity	3	2	1	4	6.5	6.5	5
	Mean	5.64	5.27	3.64	2.95	3.86	4.05	2.59
	Rank	**7**	**6**	**3**	**2**	**4**	**5**	**1**

Table 7.1.1. (cont).

		Concept						
		5	**4**	**3**	**2**	**1A**	**1**	**SA**
Marine Mammals	Blue whale	5	6	7	3	2	1	4
	Long-beaked common dolphin	5	6	7	1	4	3	2
	Short-beaked common dolphin	7	1	2	6	4.5	4.5	3
	Risso's dolphin	7	6	2	3	4.5	4.5	1
	Pacific harbor seal	6.5	6.5	5	1	4	3	2
	Southern sea otter	6.5	6.5	5	1	3.5	3.5	2
	Mean	6.17	5.33	4.67	2.50	3.83	3.17	2.33
	Rank	**7**	**6**	**5**	**2**	**4**	**3**	**1**
Composite	**Composite Mean**	5.56	5.52	4.26	3.01	3.77	3.72	2.05
	Composite Rank	**7**	**6**	**5**	**2**	**4**	**3**	**1**

7.2 SPATIAL INTEGRATION

Data and Methods

In addition to the numerical integration of OAI values, spatial data for fish, invertebrates, marine birds, and mammals were overlaid to identify areas of potential ecological importance across taxa. This allows a visual examination of the spatial coincidence of these species which may reflect ecosystem "hotspots".

Integration of datasets is a difficult task due to varying sampling techniques and issues of scale. Often, there is a disparity between spatial and temporal scales of biological data (McGowan *et al*., 1998) where inadequate spatial coverage may create unwanted bias within specific areas. As such, only datasets with similar spatial ranges and sampling techniques were considered suitable for this integration and certain datasets that were analyzed in previous chapters were not included. Based on these criteria, the datasets utilized for this analysis were the fish and invertebrate habitat suitability models (HSM) and bird and mammal sightings data (MMS, 2001). For a more complete description of these datasets refer to Chapter 3 (invertebrates), Chapter 4 (fish), Chapter 5 (birds), and Chapter 6 (mammals).

Table 7.1.2. Results of Kruskal-Wallis ranks sums test. X^2 values with probabilities less than 0.05 were considered statiscally significant.

Group	X^2	Probability	Highest Concept Ranking
Physical Setting	4.27	0.64	Study Area
Invertebrates	80.52	<0.0001	Study Area
Fish	21.1	0.0018	Study Area/ Concept 2
Birds	27.57	0.0001	Study Area/ Concept 2
Mammals	25.88	0.0002	Study Area/ Concept 2
Composite	140.19	<0.0001	Study Area

Selecting an appropriate scale to display the integrated data was crucial in order to depict trends at the smallest scale possible without making the assessment so general that the entire region becomes homogeneous. Various scales of data exist within the datasets used in this assessment: HSM data were based on bathymetric and benthic substrate data ranging from tens to hundreds of meters and bird and mammal sightings data ranged from tens to hundreds of kilometers. In order to optimize the search for pattern and to maximize the number of samples in a grid cell for the bird and mammal data, a cell size of ~950 km^2 was chosen. HSM data were then sampled into the same sized grid cells used for bird and mammal sightings, which were the limiting factor between the two types of data (Figure 7.2.1). HSM models and bird and mammal sightings data were integrated separately since they were the most comparable. Then, to provide a synoptic overview, all four data sets were combined in the final composite integration.

The areas of highest habitat suitability for all 25 fish and invertebrate species listed in Table 7.1.1 were superimposed and linked to the larger grid cells. The number of species with highly suitable habitat within each grid cell was then categorized by quintile (20%).

Bird and mammal at-sea sightings data (MMS, 2001) were examined to determine spatial co-occurrence. Sightings data for eight of the ten bird species listed in Table 7.1.1 (excluding black oystercatcher and California least tern) and four of the six mammal species (excluded Pacific harbor seal and Southern sea otter). At-sea sightings data were also available for bottlenose dolphins, gray whales, humpback whales, Pacific white-sided dolphins, Dall's porpoise, and minke whales, but lacked sufficient data for OAI analysis in Chapter 6. Presence/absence data for these species were analyzed to determine areas of co-occurrence within each grid cell. Abundance and estimated density data were not used due to difficulties in standardizing effort and sampling techniques. The number of species within each grid cell were then categorized by quintile (20%).

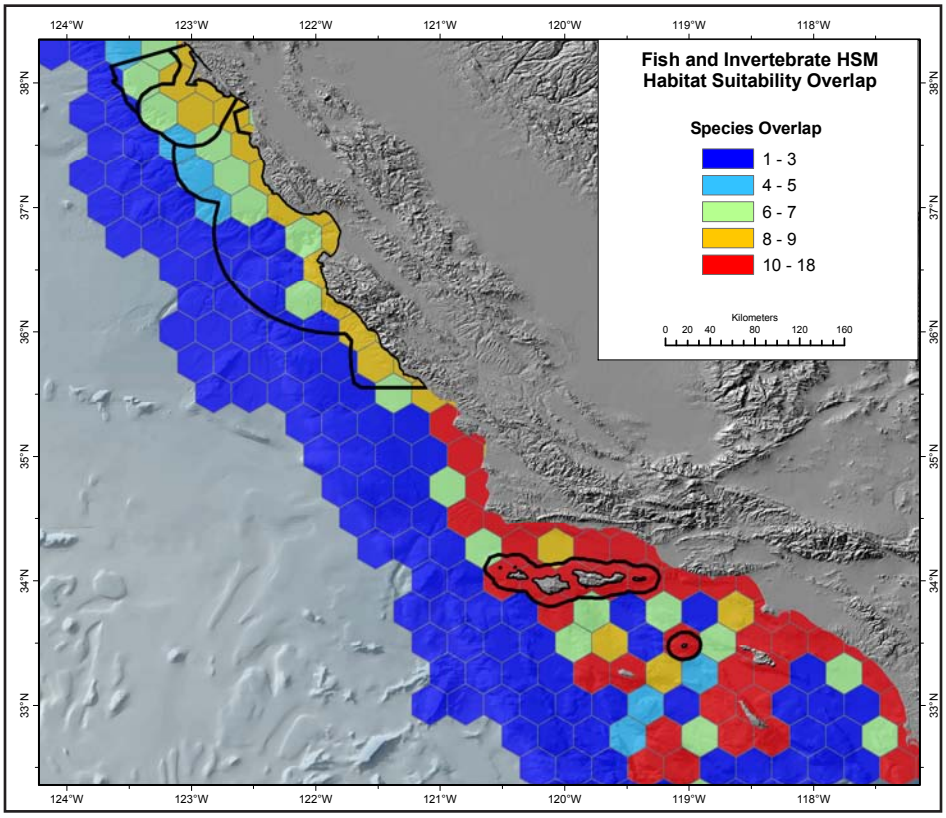

Figure 7.2.1. Broad-scale distriibution of the overlap of fish and invertebrate highly suitable habitat.

Finally, a composite integration was conducted to provide a comprehensive spatial analysis for all the datasets mentioned above. Grid cell values for fish and inveretebrate habitat suitability overlap and bird and mammal co-occurrence were summed and categorized by quintile (20%). Overall, 43 species were examined in this analysis.

Broad-scale Patterns and Analysis of Boundary Concepts

Areas of highest overlap for fish and invertebrate habitat suitability occur predominantly off southern California, from Morro Bay to San Diego (Figure 7.2.1). Overlap is lower north of Morro Bay as many of the species analyzed have southerly ranges, rarely extending north of Point Conception. Patterns of overlap were correlated with depth, where low values were observed in deep slope waters and increasing values over the continental shelf. Overlap was highest in waters near the mainland and islands off southern California.

Within southern California (Figure 7.2.2), areas of highest habitat suitability overlap occurred along the mainland from Morro Bay to San Diego, around the Channel Islands, and a large area over Cortes Bank. This pattern coincides with complex nearshore benthic habitat types, including kelp, submerged seagrass beds, rocky reefs or hardbottom, and soft substrate. This area of overlap also coincides with areas of high primary productivity (see Chapter 2.8) associated with nearshore upwelling near Point Conception and the Channel Islands (Dever, 2004).

While the patterns of overlap are broader than the original maps of suitability based on the smaller scale bathymetry and substrate maps, the analysis highlights the nearshore environment of southern California and the ecological linkages within the Santa Barbara Channel described by McGinnis (2000). Oceanographic processes in the region foster the transport of materials, such as nutrients and fish and invertebrate larvae, between the marine (islands) and coastal habitats and are primary food sources that support biological communities.

Broad-scale patterns of bird and mammal at-sea sightings data (Figure 7.2.3) identify three regions of high co-occurrence (upper 20%, 13-17 species): Point Reyes, Monterey Bay, and a large area encompassing the northern Channel Islands and extending northwest to Point Conception. Smaller areas of high co-occurrence were observed southeast of Santa Barbara Island and Cortes Bank. The regions in central California have been previously highlighted as areas supporting high bird biomass, density, and diversity (NCCOS, 2003). The highlighted areas around Point Reyes, Monterey Bay, and much of southern California have been identified as hotspots for bird diversity in this assessment (Chapter 5.2).

Within southern California, high co-occurrence was observed throughout most of the Santa Barbara Channel, including the area from Point Conception through the northern Channel Islands and smaller areas south of Santa Barbara Island and Cortes Bank. Many species of birds and mammals are widely distributed along the west coast and patterns of abundance are highly correlated with areas of high primary productivity and plankton density (Airamé *et al*., 2003; Croll *et al*., 2005). Known areas of pronounced upwelling, such as Point Conception, are generally linked with areas of high physiographic complexity and dynamic currents and eddies which tend to concentrate phytoplankton, zooplankton, and secondary consumers. (Baltz and Morejohn, 1977; Ainley and Sanger, 1979; Briggs *et al*., 1984; Briggs and Chu, 1987; Chu, 1984; Ainley *et al*., 1996; Forney and Barlow, 1998; NCCOS, 2003). The expression of the patterns observed in Figure 7.2.4 are not static and can be highly variable and difficult to predict (Mann and Lazier, 1996); however, the patterns of distribution are found near well known areas of high primary production (Huyer and Kosro, 1987; Brink and Cowles; 1991; Rosenfeld *et al*., 1994).

Based on these data, it is apparent that many bird and mammal species utilize the area between the northern Channel Islands and Point Conception. These results may be biased due to the fact that most of the bird species chosen have nesting grounds within the region.

The areas around Cordell Bank, the Farallon Escarpment, Monterey Bay, and Point Conception are well known for their productivity and diverse biological communities (NCCOS, 2003). Areas of high physiographic complexity (canyons, ridges, banks, and shelf breaks) and distinctive oceanographic features associated with seasonal upwelling

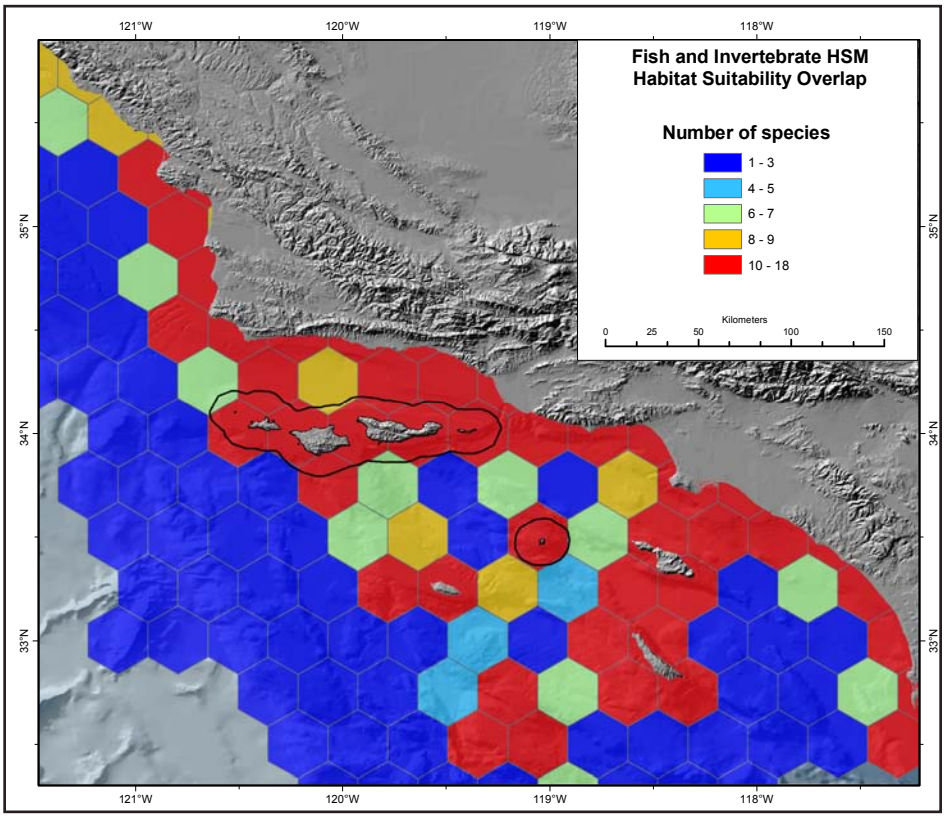

Figure 7.2.2. Overlap of fish and invertebrate highly suitable habitat off southern California.

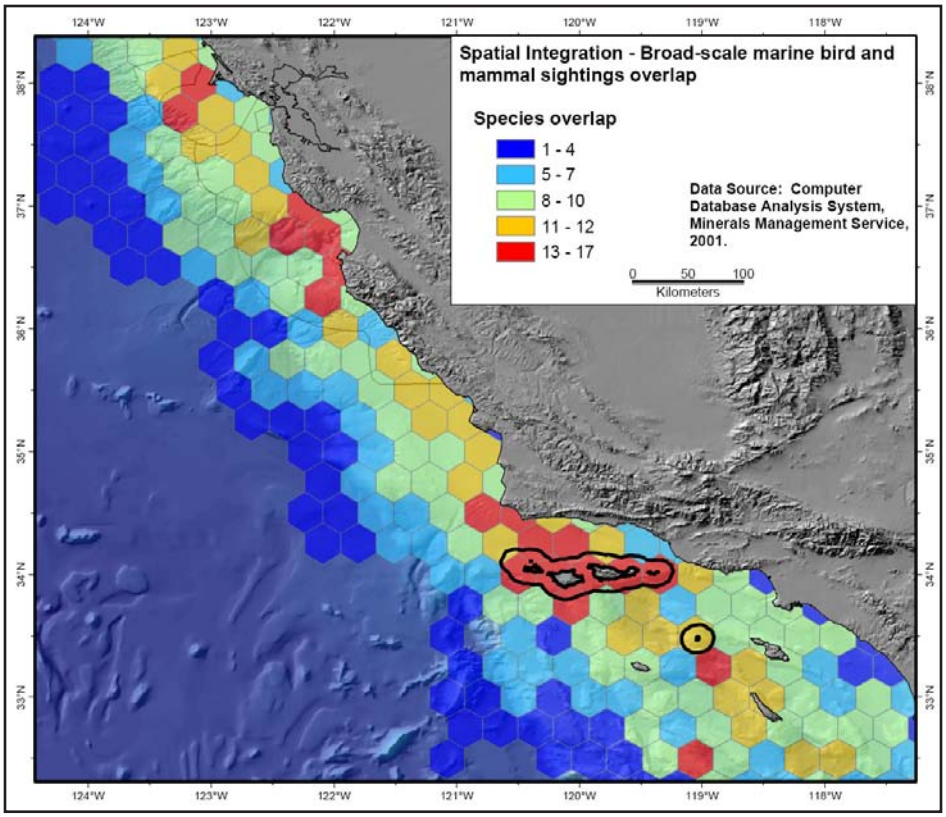

Figure 7.2.3. Broad-scale distribution of bird and mammal co-occurrence. Source: CDAS, MMS (2000).

(plumes, fronts, sea surface temperature variation, currents, and eddies) affect biological distributions patterns at many trophic levels. Broad-scale patterns for the composite of bird, fish, invertebrate, and mammal data highlight these areas of productivity. Species overlap was highest in many shelf regions with these characteristics and low in deeper habitats.

Within southern California, areas of high species overlap extend along the mainland from Morro Bay to Santa Monica Bay. A wide area encompasses the area from Point Conception to Point Dume, and south through the northern Channel Islands, including all of the Santa Barbara Channel. Another large area extends from Palos Verdes Point to San Clemente Island. Smaller areas of significance are observed around Santa Barbara Island, San Nicolas Island, and over Cortes Bank.

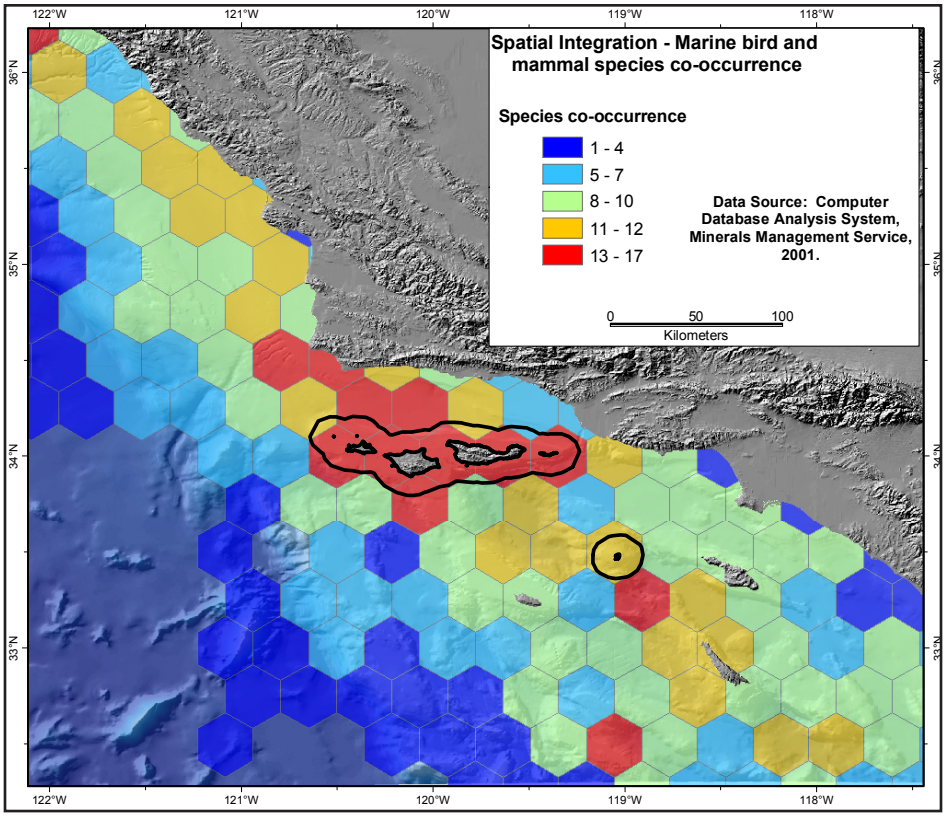

Figure 7.2.4. Bird and mammal co-occurrence off southern California. Source: CDAS, MMS (2000).

The area consisting of Point Conception and the CINMS is unique in that it is located in a transition zone between two biogeographical provinces: the warm Californian Province and the cooler Oregonian Province. Characteristics of this zone include a mix of shallow and deep water habitats, increased intensity of upwelling, dynamic eddies and surface currents, and persistent thermal fronts as a result of the meeting of the major currents (Southern California Countercurrent and California Current) from these provinces (Harms and Winant, 1998; McGinnis, 2000). This combined with important coastal habitats such as kelp, seagrass beds, and wetlands promote diverse assemblages of marine birds, fish, invertebrates, and mammals (Cross and Allen, 1993; U.S. Air Force, 1997; Schroeder, 1999; McGinnis, 2000; NCCOS, 2003). Although all species of marine birds, fish, invertebrates, and mammals were not represented in the spatial analyses, it is obvious that this transition zone is highlighted as an important ecological area for the species included in these analyses.

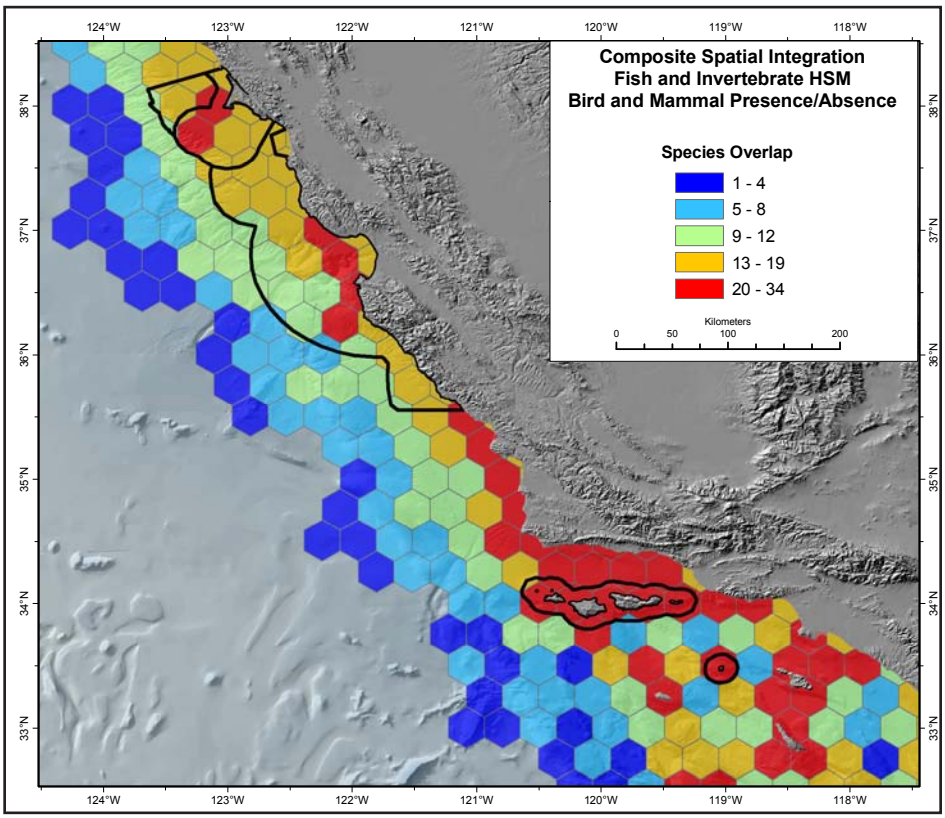

Figure 7.2.5. Broad-scale distribution of the composite spatial integration for bird, fish, invertebrate, and mammal data.

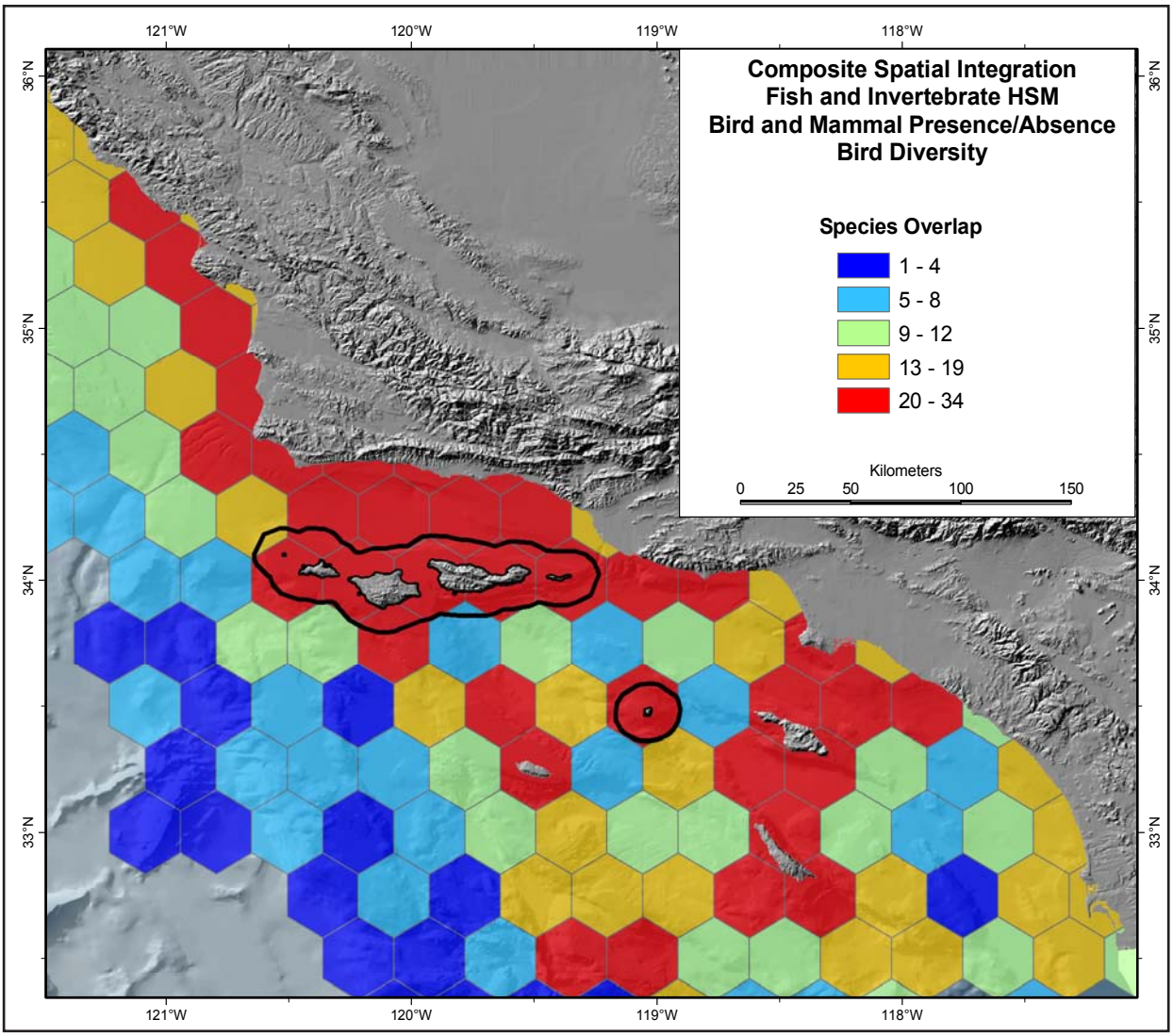

Figure 7.2.6. Composite spatial integration of bird, fish, invertebrate, and mammal data off southern California.

Summary

* The Study Area and Concept 2 ranked first and second, respectively, for most biological groups and physical processes and for the composite of all OAI analyses.

* The overlap of fish and invertebrate habitat suitability appears to be correlated with nearshore environments, predominantly kelp, seagrass beds, and rocky substrates.

* Marine bird and mammal co-occurrence appears to be associated with known centers of upwelling and primary production.

* Ecological hotspots occur in continental shelf and nearshore waters from Point Conception through the northern Channel Islands, where spatial patterns of bird, fish, invertebrate, and mammal habitat overlap.

7.3 THREATENED AND ENDANGERED SPECIES

Seven of the species considered in this bioassessment are listed as threatened or endangered under the Endangered Species Act of 1973:

White abalone	*Haliotis sorenseni*	Endangered
Western snowy plover	*Charadrius alexandrinus nivosus*	Threatened
California brown pelican	*Pelecanus occidentalis californicus*	Endangered
California least tern	*Sterna antillarum browni*	Endangered
Southern sea otter	*Enhydra lutris nereis*	Threatened
Blue whale	*Balaenoptera musculus*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered

Biogeographic patterns of these species, with respect to the boundary concepts, are recapped for each of these species.

White abalone

Approximately 77 km^2 of habitat were considered suitable for white abalone within the current CINMS sanctuary boundary (NAC). This estimate remained the same for the smaller Concepts 2, 3, 4 and 5 (Table 7.3.1). The addition of nearshore waters along the mainland for the Study Area and Concepts 1 and 1a provide additional suitable habitat. The OAI analysis indicates that these larger concepts (SA, 1, and 1a) offer the greatest proportional change in habitat area/total area gained relative to the NAC.

Table 7.3.1. Analysis of white abalone habitat suitability within boundary concepts.

Concept	High Suitability Area (km^2)	Δ Area (%)	Δ High Suitability Area (%)	OAI (absolute)
NAC	77	-	-	-
5	77	21.12	0	0
4	77	113.11	0	0
3	77	141.50	0	0
2	77	266.78	0	0
1a	93	503.23	20.78	0.04
1	93	503.82	20.78	0.04
SA	*93*	*356.42*	*20.78*	*0.06*

Western snowy plover

290 km of coastline along the U.S. Pacific coast (Washington, Oregon and California) have been designated as critical habitat for the western snowy plover (USFWS 1999). The current CINMS sanctuary boundary (NAC) and Concepts 4 and 5 do not include any designated critical habitat (Table 7.3.2). Concept 3 includes 2.3 km of critical habitat shoreline, less than 1% of the total designated habitat. Concept 2 encompasses 27.4 km (9.4%). The larger Concepts 1, 1a and the Study Area include 24% (70 km) of the designated western snowy plover critical habitat. Because there was no critical habitat designated within the NAC, it is not possible to calculate the OAI for western snowy plover critical habitat.

Table 7.3.2. Critical habitat for the Pacific coast population of western snowy plover.

Concept	Critical Habitat: Length of Shoreline (km)
NAC	-
5	0
4	0
3	2.29
2	27.35
1a	69.85
1	69.85
SA	*69.85*

California brown pelican

Analysis of the observed patterns of pelican sightings and density relative to the proposed boundary concepts indicates that the Study Area and Concepts 1 and 1a provide the greatest increase in sightings (absolute metric) for its relative size compared to the NAC (Table 7.3.3). The density-based OAI, however, favors Concept 5, the smallest concept. The smaller concepts (3-5) fail to capture the region of high pelican density along the mainland coast and in the eastern Santa Barbara Channel, while the largest concepts (1 and 1a) include large areas of low pelican density along the shelf.

No analysis of boundary concepts was conducted for brown pelican breeding colonies since none of the concepts encompass any colonies not contained in the NAC.

Table 7.3.3. California brown pelican sightings and density OAI.

Concept	Total Individuals	Density (Individuals/km^2)	OAI (absolute)	OAI (relative)
NAC	374	0.834	-	-
5	452	0.918	0.99	0.47
4	540	0.722	0.39	-0.12
3	913	0.927	1.02	0.08
2	1355	0.853	0.98	0.01
1a	2546	1.035	1.15	0.05
1	2546	1.035	1.15	0.05
SA	*2546*	*1.204*	*1.63*	*0.12*

California least tern

There were no recorded breeding colonies of least tern within the NAC or Concepts 3-5 during 2001–2003 (Table 7.3.4). Concept 2 encompasses 1 colony at Vandenberg AFB for a maximum of 79 breeding pairs. Concepts 1 and 1a and the Study Area encompass an additional 4 colonies for a maximum of 676 breeding pairs. Because no colonies exist within the NAC, it is not possible to calculate the OAI for least tern colonies.

Table 7.3.4. California least tern breeding pairs observed within boundary concepts, 2001-2003. Source: CDFG, draft data.

Concept	Maximum Breeding Pairs
NAC	0
5	0
4	0
3	0
2	79
1a	676
1	676
SA	*676*

Southern sea otter

Substantial differences exist among the six boundary concepts in terms of their potential impacts on sea otters. The current boundary and Concepts 4 and 5 include only the small population at San Miguel Island. Reliable estimates of the size of this population are not available. Concepts 1, 1a, 2, and 3 all include portions of the mainland coast (Table 7.3.5). To the extent that sea otter protection is a goal of the CINMS, Concepts 1, 1a, and 2 offer the greatest benefit. All of these options incorporate portions of the coast between Point Conception and Point Sal, which is in the primary range of the Southern sea otter. At this point in time, Concepts 1 and 1a appear to encompass little additional sea otter habitat than encompassed by Concept 2. If the southern sea otter's range continues to expand, however, the additional section of mainland coast to the south of Santa Barbara that is included in Concepts 1 and 1a may become important habitat. Based on the most recent available surveys of sea otters, Concept 2 provides the greatest benefit in terms of sea otters encompassed by the boundaries for the smallest relative change in area. The OAI results support this conclusion for both the spring and fall survey data.

Table 7.3.5. Spring and fall abundance estimates and OAI for southern sea otter.

Concept	Spring/Fall Total Individuals	Spring/Fall Average Mainland Encounter Rate (#/km)	OAI Spring	OAI Fall
NAC	8	-	-	-
5	8	NA	0	0
4	8	NA	0	0
3	17	1.00	0	0
2	130	0.54	0	0
1a	140	0.47	20.78	0.04
1	140	0.47	20.78	0.04
SA	*140*	*0.47*	*20.78*	*0.06*

Blue whale

Because of the relatively small number of on-effort sightings (4-14) and the uncertainty in the line transect input parameters, confidence intervals for the abundance estimates are wide and overlap substantially among the concepts (Table 7.3.6). The NAC does seem to be well placed to capture regions of high blue whale density within the Southern California Bight as it exhibits higher estimated density than any of the other concepts. Sharp increases in estimated blue whale abundance relative to that of the NAC are apparent in Concepts 1, 1a, and 2. The OAI shows that, although none of the concepts provide higher density than the NAC, Concepts 1 and 1a provide the greatest relative increase in blue whale abundance for the relative increase in area.

Table 7.3.6. Sightings, estimated abundance and density, and OAI for blue whales.

Concept	Sightings	Density (individuals/km^2)	Estimated Abundance	OAI (absolute)	OAI (relative)
NAC	4	0.00807	30	-	-
5	4	0.00712	32	0.316	-0.557
4	4	0.00400	32	0.059	-0.446
3	4	0.00358	32	0.047	-0.393
2	7	0.00600	82	0.650	-0.096
1a	14	0.00587	133	0.680	-0.054
1	14	0.00587	133	0.681	-0.054
SA	*8*	*0.00530*	*91*	*0.570*	*-0.095*

Humpback whale

Because some of the sightings recorded as "Unidentified Large Whale" (including one that fell in Concepts 1 and 1a) were likely to be humpback whales (Carretta et al. 2002), abundance estimates in Concepts 1 and 1a may be negatively biased. Very small numbers of sightings (0-4) make the density and abundance estimates for this species extremely uncertain. No sightings were recorded within the NAC and only 1 sighting was recorded in Concepts 3-5 resulting in abundance estimates of approximately 10 individuals for these three concepts (Table 7.3.7). Four sightings occurred in Concepts 1, 1a, 2 and the study area, resulting in abundance estimates of approximately 50 individuals for these four areas. Because no sightings were recorded in the NAC, it was not possible to calculate the OAI for humpback whales.

Table 7.3.7. Sightings, estimated abundance and density for humpack whales.

Concept	Sightings	Density	Estimated Abundance
NAC	0	0	0
5	1	0.00234	11
4	1	0.00131	10
3	1	0.00118	11
2	4	0.00375	52
1a	4	0.00230	51
1	4	0.00226	51
SA	*4*	*0.00310*	*13*

Summary

Table 7.3.8 provides a summary of the boundary concept metrics for each of the Federally-listed species. Numerical values for each concept are ranked in ascending order (highest values receive the lowest rank); ranks for tied values are averaged. For species that do not have an OAI calculation for each concept (i.e. when the ecological metric was 0 inside the current sanctuary boundary), rankings were based upon a modified OAI, calculated as:

$$OAI_{modified} = B_1\text{-}B_0/A_1\text{-}A_0$$

where B_1-B_0 equals the difference of the metric (diversity, habitat area, etc) and A_1-A_0 equals the difference of total area between a given boundary concept and the NAC. This modified metric omits the relative weighting of the NAC to the difference in ecological value and the difference in area; however, it is suitable for ranking the concepts as it maintains the relative relationships between the gains in ecological value per gain in total area. As discussed in the Introduction, absolute metrics inherently favor the largest concept because each successively larger boundary encompasses the smaller concept. Accordingly, the Study Area and the larger concepts 1,1a and 2 are generally more favorable than the smaller concepts. This is generally upheld for metrics that are based on either absolute or OAI values.

Table 7.3.8. Ranked OAI for the 86 federally listed threatened or endangered species.

Concept	1	1a	2	3	4	5	SA
Area (km^2)	22613	22591	13736	9044	7981	4536	17093
White abalone High Suitability area	2.5	2.5	5.5	5.5	5.5	5.5	1
Western snowy plover critical habitat (km)	2.5	2.5	4	5	6.5	6.5	1
California brown pelican Total Individuals	2.5	2.5	6	4	7	5	1
California least tern Breeding Pairs	2.5	2.5	4	6	6	6	1
Southern sea otter Mean Individuals across Spring and Fall	3.5	3.5	1	5	6.5	6.5	2
Blue whale sightings	1.5	1.5	3	7	6	5	4
Humpback whale Estimated Abundance	3.5	3.5	2	6	5	1	7
Overall Ranking	**2.5**	**2.5**	**4**	**6**	**7**	**5**	**1**

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