CHAPTER 1 INTRODUCTION

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1.1 PROJECT BACKGROUND

The National Marine Sanctuary Program (NMSP) is currently updating and revising the management plans for each of its 13 sanctuaries. This process, which is open to the public, enables each site to revisit the reasons for sanctuary designation and assess whether they are meeting their goals, as well as to set new goals consistent with the mandates of the National Marine Sanctuaries Act. Issues raised by the public during this process are evaluated and a determination is made as to whether they will be incorporated into the updated plan. Many of these issues focus on topics such as the implementation of marine zoning or sanctuary boundary adjustments, both of which require information on the distribution of resources within and around the sanctuary. Recognizing this, NMSP and NOAA's National Centers for Coastal Ocean Science (NCCOS) formalized an agreement to collaborate in the revision process by developing such information through a series of biogeographic assessments conducted in selected sanctuaries. The resulting products are then supplied to sanctuary managers and staff for use in the policy and decision making process. This collaborative effort began along the west coast of the U.S. with the Cordell Bank, Gulf of Farallones, and Monterey Bay national marine sanctuaries, and is herein centered on the Channel Islands National Marine Sanctuary (CINMS).

The current CINMS boundaries (Figure 1.1.1) were selected to provide adequate protection of local marine plants and animals given the nature of adjacent human uses and based on the limited information on the spatial distribution of threats, biota, and habitats that were available in 1980, the year the sanctuary was created. However, the CINMS management plan has not been updated since 1983 and new management issues have subsequently arisen, as has the availability of pertinent biological information. As a result, CINMS was one of the first sanctuaries to begin the management plan review process, which was initiated along with the formation of the Sanctuary Advisory Council in 1998. This was followed by a series of seven "public issue" scoping meetings along the coast of southern California and Washington D.C. in 1999.

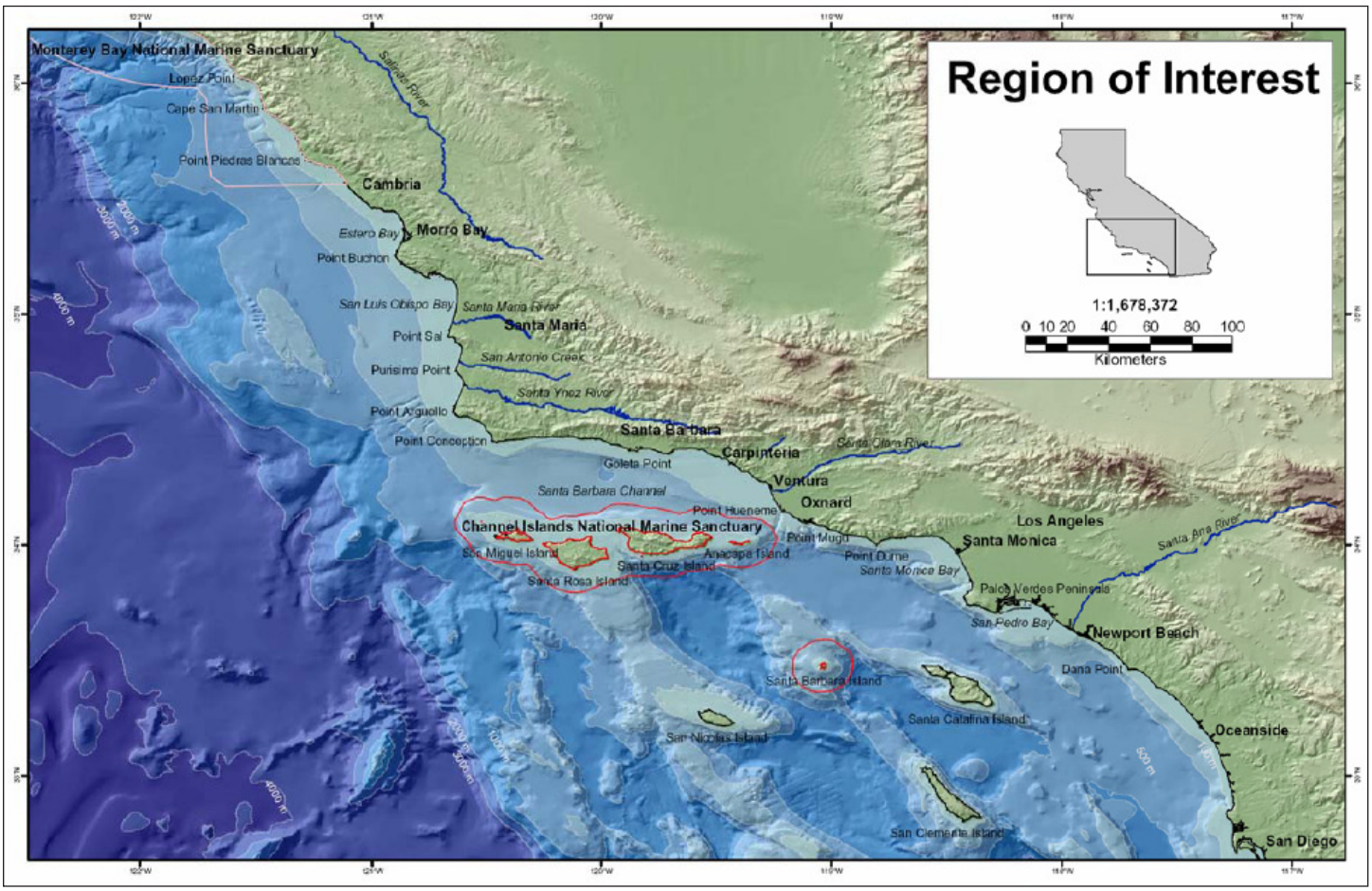

Figure 1.1.1. Map of the Channel Islands and specific coastal locations in the surrounding region of interest. The red lines indicate the current boundaries for the Channel Islands National Marine Sanctuary and the pink line to the north is the southern boundary of the Monterey Bay National Marine Sanctuary.

Three main factors have driven the sanctuary's interest in considering a change to the CINMS boundaries: 1) an emerging understanding of how the sanctuary's living resources are integrally connected to marine areas outside the CINMS boundary, 2) heightened awareness of human activities occurring outside the sanctuary that could pose threats to CINMS resources, and 3) high public interest in boundary expansion as expressed clearly during the 1999 public scoping meetings. These factors have been considered as the sanctuary's management plan review process has evolved.

The issue of expanding the sanctuary's boundary was first raised during public scoping meetings held in 1999, and has been an issue of continued interest to numerous constituents. A large number of scoping comments received suggested that sanctuary boundaries be expanded to incorporate more of the regional marine ecosystem and to allow CINMS to better address management issues associated with coastal watersheds, oil and gas development, water quality, and military activity. Other comments received were not in support of boundary expansion.

Following the scoping meetings, sanctuary staff worked closely with the Sanctuary Advisory Council and other constituents to better understand and assess issues underlying the possible need for expanding CINMS boundaries. In 2000, a literature review was commissioned to help understand the geographic range of ecological linkages among species and habitats found within the sanctuary (McGinnis, 2000). As a result of this assessment, the author recommended the area from Point Mugu northward to Point Sal (Figure 1.1.2a) as a connective unit. This area is referred to as the Study Area throughout this assessment.

A range of initial boundary "concepts" then emerged from meetings and workshops held with the Sanctuary Advisory Council in 2000 and 2001. In assisting with the design of boundary concepts, Sanctuary Advisory Council members considered the known locations of key or unique habitats, oceanographic processes, marine species, marine and coastal human activities, potential threats to sanctuary resources, ease of boundary identification, and other factors. The resulting six boundary concepts ranged in scope from the existing CINMS boundary, the "No Action Concept" (NAC), to an expansion to the coastal mainland extending from Point Sal in the north to Point Mugu to the south (Figure 1.1.2a).

The current CINMS boundary was designated under the authority of Title III of the Marine Protection, Research and Sanctuaries Act of 1972, now known as the National Marine Sanctuaries Act, and has remained unaltered since its establishment. The sanctuary is located in the Southern California Bight, 40 kilometers off the coast of Santa Barbara, California. It encompasses 3,745 km^2 of seawater, and extends from the mean higher high water line to six nautical miles offshore around the northern Channel Islands (San Miguel, Santa Rosa, Santa Cruz and Anacapa) and Santa Barbara Island (Figure 1.1.1).

Boundary Concept 1 includes the entire Study Area recommended by McGinnis (2000), plus an additional portion over part of the Santa Lucia Bank. As the largest boundary concept, it encompasses the widest range and variety of habitats. Human uses encompassed include oil and gas exploration and development, commercial and recreational fishing, other types of recreation, harbors, watersheds and military use. This is the only concept that includes coastal areas adjacent to harbors. Concept 1a resembles Concept 1, except for the exclusion of offshore oil and gas leases and coastal ports and harbors (Figure 1.1.2a).

Concept 2 incorporates much of the Study Area, and its area contains 62% of Concept 1. Unlike Concepts 1 and 1a, the mainland coastal component of Concept 2 begins at Gaviota and extends slightly north of Point Sal thereby excluding the more urbanized areas of the mainland coast. Unlike the larger boundary concepts, the northward boundary of Concept 3 does not incorporate Point Arguello. It extends from the southern boundary of Vandenberg Air Force Base, south past Point Conception and east past Cojo Anchorage. The mainland coast component of Concept 3 extends to a small fraction of the mainland coastline including Point Conception, without overlapping state or federal oil and gas leases and without adjoining any urban coastal areas (Figure 1.1.2a).

Concepts 4 (Figure 1.1.2a) and 5 (Figure 1.1.2b) include only offshore areas and do not include habitats associated with the mainland coast, such as mainland kelp beds, wetlands, and linkages to coastal watersheds. Concept 4 encompasses a larger area than the existing CINMS boundary, providing a contiguous connection between the northern Channel Islands and Santa Barbara Island. Concpet 5 is closest among the concepts to the existing sanctuary boundary, and essentially squares off the curved sanctuary boundary to aid in boundary

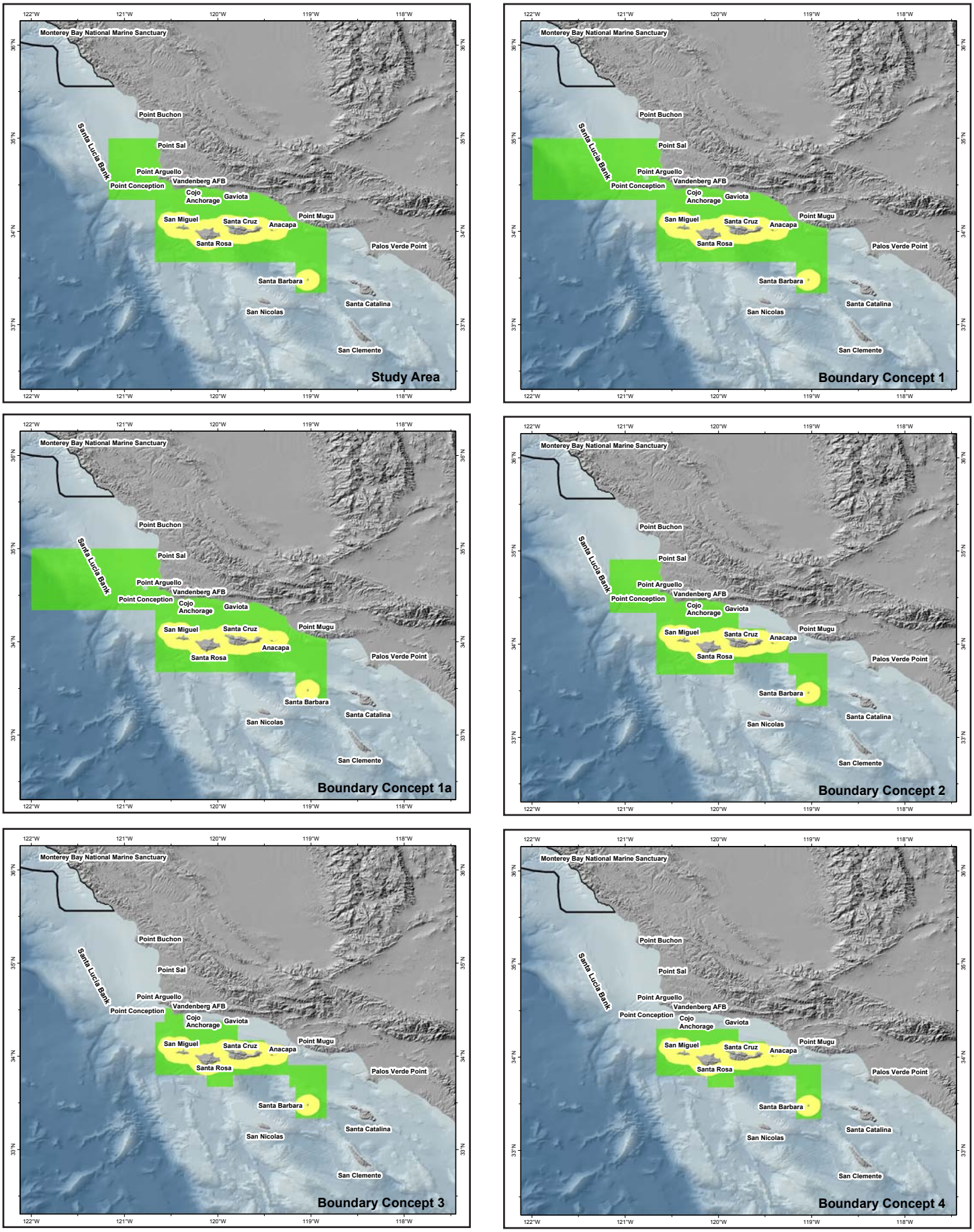

Figure 1.1.2a. Spatial delineations for the Study Area and boundary Concepts 1-4.

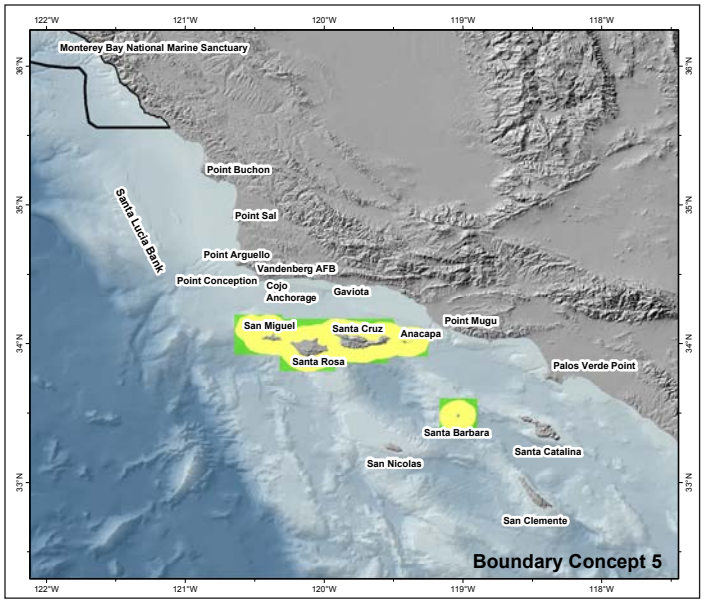

Figure 1.1.2b. Spatial delineation for boundary Concept 5.

Table 1.1.1. Total area, perimeter, and amount of mainland coastline included for the NAC, Study Area, and six boundary concepts.

	Area (km^2)	Perimeter (km)	Mainland Coastline (km)
NAC	3745	653.34	0.00
5	4536	708.72	0.00
4	7981	831.00	0.00
3	9044	903.67	20.32
2	13736	1074.90	140.02
1	22613	1220.10	277.64
1a	22591	1239.23	277.64
SA	*17093*	*1069.52*	*277.64*

identification for enforcement, charting and navigation purposes. Total area and amount of mainland coastline are displayed in Table 1.1.1.

In 2001, the Sanctuary Advisory Council was unable to reach a consensus on which of the six boundary concepts to endorse, and the issue remained controversial with a variety of stakeholders. In 2002, following the Advisory Council discussions, the NMSP in consultation with the NOAA Administrator determined that there was a need to conduct additional data collection and analyses in order to make an appropriately informed decision on boundary expansion. In particular, it was determined that a detailed study of the Channel Islands regional biogeography was needed and would be conducted by NCCOS. Hence, the revised draft management plan and associated Draft Environmental Impact Statement (DEIS) do not contain an analysis of the boundary concepts discussed herein.

In 2003, NCCOS was asked by the NMSP to evaluate (from a biogeographic perspective) the six boundary concepts that had been previously developed by sanctuary staff and the Advisory Council, including the NAC. Identifying how these alternatives correspond to the distribution of critical biotic and habitat resources is a necessary component of assessing the qualities of one alternative over another. However, it is important to note that this biogeographic study is not a decision-making document for NOAA; rather, this study will help inform any future decision-making on sanctuary boundary change.

Currently, the NMSP plans to incorporate and build on this biogeographic study, as well as previous work, to prepare a Supplemental Environmental Impact Statement (SEIS) that will present and fully analyze boundary change concepts (including the option of not changing the boundary). In compliance with the National Environmental Policy Act (NEPA), the potential environmental and socioeconomic impacts associated with any boundary change will be analyzed in the SEIS and made available for public review and comment. The process will be open and transparent to the public, involving significant discussion and input from the Advisory Council and other interested agencies and parties. After consideration and incorporation of comments received on the SEIS, a final agency determination on sanctuary boundary change will follow. Additional information about the public process conducted from 1999-2001 that led to the development of the seven boundary concepts analyzed in this report is currently available on the CINMS web site at the following locations: General background on the boundary change issue-http://channelislands.noaa.gov/manplan/boundaries.html; Sanctuary Advisory Council involvement with this issue-http://channelislands.noaa.gov/manplan/history.html; McGinnis (2000) report-http://www.channelislands.noaa.gov/manplan/documents.html.

This biogeographic assessment was made possible by a wealth of studies, local assessments (e.g., marine reserves analyses), and advancements in remote sensing that have provided a variety of new spatial data that can be used to support selection of a boundary. This work complements and builds upon a similar effort recently

completed by NCCOS for three sanctuaries in central and northern California (Cordell Bank, Gulf of the Farallones, and Monterey Bay national marine sanctuaries; NCCOS, 2003). The biogeographic assessment for these three sanctuaries was conducted to identify important biological zones, time periods, and ecological linkages within an area that extends from Point Arena in the north to Point Sal in the south. The overlap in flora and fauna as well as the expertise of the research community allowed NCCOS to take advantage of contacts and data sources already developed through this earlier work. In addition, a supplemental report was developed for this prior assessment which describes the key ecosystems, species, and interactions occurring within that study region (Airamé *et al*., 2003). While the focus of the report was on central and northern California, it describes the surrounding regions as well. As a result, much of the current study draws on the information gathered and analyses conducted as part of that effort. With the addition of this report and biogeographic assessment, there is now integrated biogeographic information compiled for the California coastline from Pt. Arena south to the U.S. – Mexico border. This framework provides for future broad-scale analysis that goes well beyond the boundaries of individual sanctuaries and provides a strong foundation for managing sanctuaries not as isolated areas but as a network of interconnected habitats.

This assessment was conducted for the marine waters surrounding California's Channel Islands and represents the culmination of a 24-month collaboration between NCCOS and CINMS. It was greatly assisted by the generous support of time and data provided by numerous researchers along the entire west coast. While the immediate focus of this assessment was to evaluate a series of boundary expansion concepts for the sanctuary, a biogeographic study such as this one should help to inform managers who need to make other spatially explicit management decisions for this region. Additionally, this assessment represents a summary of existing comprehensive, large-scale data sets. Missing Taxa or areas not covered may provide the driving force for future research necessary to fill these gaps. This assessment only considers biological, geological, and physical oceanographic data, and does not include other boundary analysis criteria (e.g. socioeconomics, management feasibility) that will be utilized by the NMSP management to make the ultimate decision in selecting a boundary alternative from the SEIS.

1.2 INTRODUCTION TO BIOGEOGRAPHY

Biogeography is the study of the geographic distribution of species. More specifically, it is the study of the relationship of species' distribution patterns relative to geographical differences in the environment. It focuses on large-scale patterns in species distributions and classifies them into biogeographic regions, provinces, and life zones. Biogeographic regions are related to global climatic zones, with latitudinal differences in ranges of temperature, day length, and primary production. These are all important variables affecting distribution. Biogeographic provinces are biotically distinct geographic areas within a biogeographic region, and hence have similar ranges of day length and temperature but are distinct in other environmental characteristics. Life zones in the ocean generally represent major changes of environmental conditions (e.g., estuarine, coastal, open ocean) or bathymetric zones (with decreasing temperature and ambient light and increasing pressure occurring with increasing depth) (Hedgpeth, 1957; Allen and Smith, 1988; Allen, in press). Biogeographic provinces and life zones are adaptive, in that species living there must have specific adaptations to the environmental characteristic of the province or zone (e.g., to temperature range, seasonality of production, bathymetric pressure, light levels, etc.). Hence, the biota of these provinces and zones has developed over evolutionary time (Briggs, 1974; Allen, 1982a; Briggs, 1995).

Throughout a biogeographic province, one might expect to find the same set of species occurring in a given habitat in a given life zone (Allen, 1982a; b). Similarly in an adjacent biogeographic province, one would find a somewhat different set of species in the same habitat in the same life zone (Allen, in press). While some species would be unique to each province, some broadly ranging species would occur in both provinces (Allen and Smith, 1988). Where two adjoining provinces (or life zones) meet, there is an ecotonal region where species common in each are found in lower abundance. With distance from the ecotone center these incidental species become less important and predictable to a community in a given habitat.

It is important to understand the relative fidelity to and abundance of a species in a specific area. The distribution of biogeographic provinces has been relatively stable since the last ice age, although the location of boundaries between provinces varies somewhat with large-scale periodic and aperiodic climate changes (e.g., Pacific decadal oscillation, El Niño) (Allen *et al*., 2004). A species is typically more common and abundant within the

main part of the biogeographic province(s) where it occurs. It occurs less frequently with greater variation of abundance near the end or outside of its typical biogeographic province (Andrewartha and Birch, 1954).

Biogeographic assessments are important because they focus on the large-scale distribution of species rather than on local occurrences of species and hence provide the basis for predicting biota for a given habitat within a biogeographic province. Assessments of specific species involves mapping nursery grounds, spawning areas, feeding areas, migratory routes, and areas where they are fished (NOAA, 1990). This provides valuable information for determining essential habitat for protection. In addition to the information these assessments provide on a single species, they can provide information on the distribution of species diversity and richness of biota. Furthermore, these assessments help to identify which species form assemblages or communities, and how population and community measures, such as species diversity and richness, vary in the region.

Biogeographic assessments are useful to coastal managers because they provide a basis for determining components of the biota that are typical of an area and are appropriate for management of species or habitats. Local assemblages are composed of species that are representatives of the biogeographic community and species that are incidental to the area (Allen, 1982a; b). In the former case, because of their persistence in the population, representative species can be more readily managed. In the latter case, incidental species are likely to vary greatly over time, either by chance or in response to climatic change, making management less likely to be successful in the long term.

1.3 BIOGEOGRAPHY OF THE WEST COAST

A number of biogeographic provinces and life zones occur along the California coast. There are two coastal biogeographic provinces: Oregonian and San Diegan. The Oregonian Province primarily extends from southeastern Alaska to Point Conception, and is part of the Eastern Boreal Pacific Region (Briggs, 1974; 1995). The Oregonian Province also extends southward beyond Point Conception along the outer islands of southern California, and in part reappears in upwelling areas off Baja California (Hubbs, 1949). The San Diegan Province (part of the warm-temperate California region, which also includes the Cortez Province of the Gulf of California) extends from Point Conception, California to Magdalena Bay, Baja California Sur (Briggs, 1974). However, in warm-regime years, some San Diegan species extend their ranges northward. Offshore are two provinces of the cold-temperate Oceanic Boreal Pacific Region. Offshore are two provinces of cold-temperate Ocean Boreal Pacific Region (McGowan, 1971). The Subarctic Province extends south along the California coast to Cape Mendocino, and the Transition Zone extends south from Cape Mendocino to Magdalena Bay.

Several pelagic and benthic life zones occur in this region (Allen and Smith, 1988). Pelagic life zones consist of the Neritic Zone (water column over shelf to 200 m isobath) and three oceanic zones (over slope and basins): Epipelagic Zone (surface to 200 m); Mesopelagic Zone (200-1000 m); and Bathypelagic Zone (1000-4000 m; Figure 1.3.1). Benthic life zones (Allen, In press) include Intertidal, Inner Shelf (0-30 m), Middle Shelf (30-100 m), Outer Shelf (100-200 m), Mesobenthal (Upper) Slope (200-500 m), and Bathybenthal Slope (500-1000 m; Figure 1.3.2). A separate Estuarine Zone consists of both water-column and benthic species (Hedgpeth, 1957).

Coastal biogeographic provinces differ in their distribution with depth, with the Oregonian Province extending further south with each successive benthic life zone (Allen, In press). In some cases, submergence occurs, with species occurring in shallow depth zones in central and northern California occurring in deeper life zones in southern California (Hubbs, 1949; Allen, In press).

The Channel Islands lie at the intersection between the warm-temperate San Diegan biota and the cold-temperate Oregonian biota. The California Current (which largely defines the California part of the Oregonian Province), flows south on the outer edge of the Southern California Bight (SCB) below Point Conception as the coast of southern California turns abruptly eastward. This current intersects the coast near Cape Colnett, Baja California (forming the southern end of the SCB). Part of the current flows north into the SCB, forming a large eddy, with warm water dominating the inner part of the SCB. This warm water zone comprises the southern California part of the San Diegan Province, whereas the outer islands of the SCB (San Miguel, Santa Rosa, and San Nicolas islands) largely have an Oregonian biota. Santa Cruz Island (eastern part), Anacapa Island, Santa Barbara Island, Santa Catalina Island, and San Clemente Island largely have a San Diegan biota (particularly the latter two islands). In a recent report by Airamé *et al*. (2003) describing the biogeography and ecological linkages of

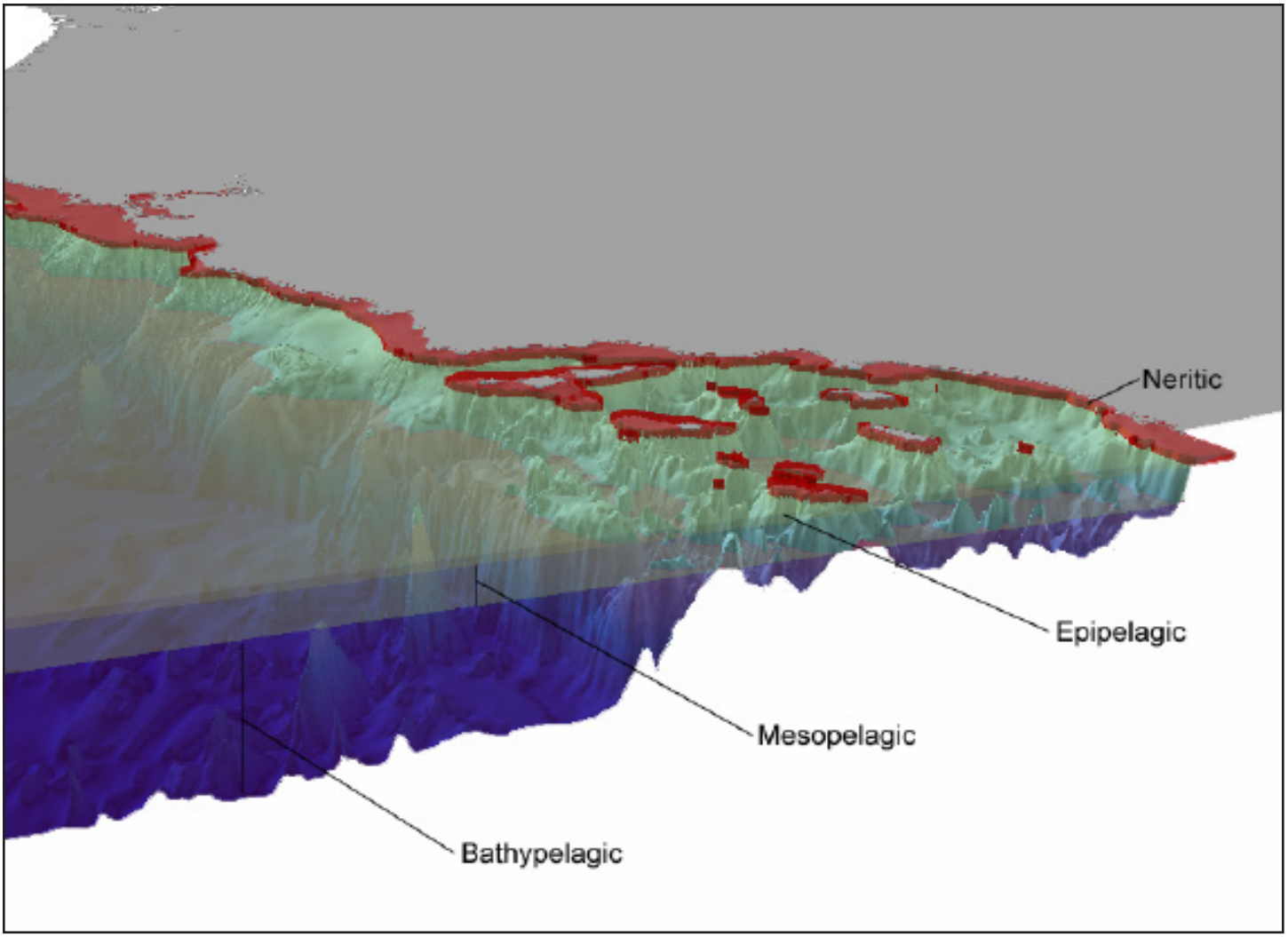

Figure 1.3.1. Pelagic life-zones off southern California.

marine and estuarine ecosystems of central and northern California, a range endpoint analysis was conducted on eastern Pacific marine invertebrates, fishes, birds, and mammals to look for biogeographic breaks in their distributions along the west coast of North America. The transition zone between the Oregonian and San Diegan provinces, which is located within the region of interest, is emphasized as a result of these analyses. A short discussion of the results is presented below.

Latitudes where the northern or southern extent of many species' ranges end often corresponded to major oceanographic features. For example, at Point Conception (a known biogeographic boundary described above), the cool water of the California Current intersects with the relatively warm water of the California Countercurrent, which flows north along the coast of southern California. These areas were highlighted graphically in Figures 1.3.3-1.3.6, where the longer bars equate to a greater number of species with range termini at the given latitude. The portion of the graphs enclosed by a black box highlight range endpoints within the region of interest. Analyzing latitudinal trends in this manner is a common technique applied to examine patterns of distribution, diversity, and structure in marine populations (Horn and Allen, 1978; Roy *et al*., 1994; Dawson, 2001). This type of information can, in turn, be used to identify distinct regions or transitional zones in the marine environment and allow managers a better understanding of their resources when making informed place-based management decisions.

Marine Benthic Invertebrates

The database used in this analysis (Figure 1.3.3) included 539 species of marine benthic invertebrates from the coast of California (G. Eckert, unpublished data). Information about each species was gathered from the primary literature and included the northern and southern range endpoints to the nearest 0.5° latitude. Results indicate significant transitions in fauna occurring at San Diego (32.5°N), the Channel Islands/Pt. Conception (33-34.5°N),

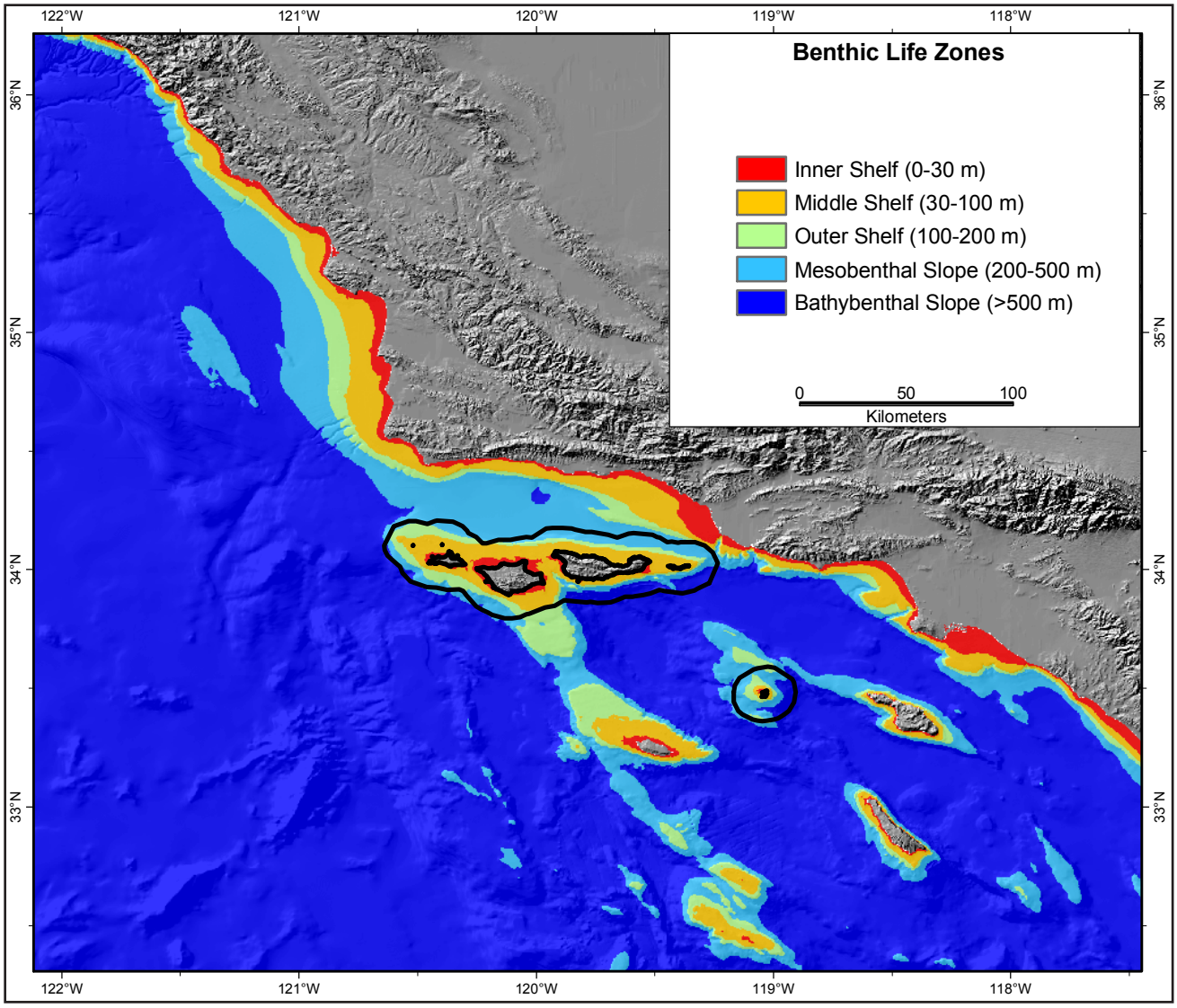

Figure 1.3.2. Benthic life-zones off southern California.

and Monterey Bay (36.5°N) with additional biogeographic breaks at Vancouver Island (49.5°N) and the Aleutian Islands (53°N). The large number of range endpoint peaks (both northern and southern) within the region of interest indicate that this is a transition zone where southern species are reaching their northern limits and are being replaced by northern species at their southern limits. Historical studies also support the findings shown here. Major barriers for eastern Pacific mollusks from Alaska to Baja California were found to occur at Vancouver Island (48-49°N), the northern Channel Islands (34.4°N), and Punta Eugenia (28.2°N) (Roy *et al*., 1994). Within California, Point Conception and Monterey Bay are recognized as biogeographical boundaries for ascidians, crabs, and shallow-water benthic mollusks (Hayden and Dolan, 1976; Valentine, 1966). Within southern California Newell (1948) found concurrent range endpoints at both San Clemente Island (33°N) and the northern Channel Islands (34°N) for marine mollusks.

Marine Fishes

Northern and southern range endpoints of 294 Pacific coast fishes obtained from Eschmeyer *et al*., (1983) are shown to the nearest 0.5° latitude (Figure 1.3.4). The overwhelming majority of range endpoints occur along the central and southern California coasts. The four major biogeographic transitions starting in the south occur at San Diego (32.5°N), the Channel Islands/Pt. Conception (33.5-34°N), Monterey Bay (36.5°N) and finally San Francisco/Point Reyes (37.5°N). A few minor shifts in species composition occurred at Cape Mendocino (40.5°N), Vancouver Island (49.5°N), the Aleutian Islands (54°N), Kodiak Island (57.5°N) and Prince William Sound (60.5°N). As in the case of benthic marine invertebrates, the large number of range endpoint peaks (both northern and southern) within the study area indicate that this is a transition zone where southern species are reaching their northern limits and are being replaced by northern species at their southern limits. The two dominant orders within this sample of fishes, Perciformes (N=122) and Scorpaeniformes (N=78), exhibit different biogeographic patterns. Perciform fishes are generally distributed south of Point Reyes, which is the most distinct

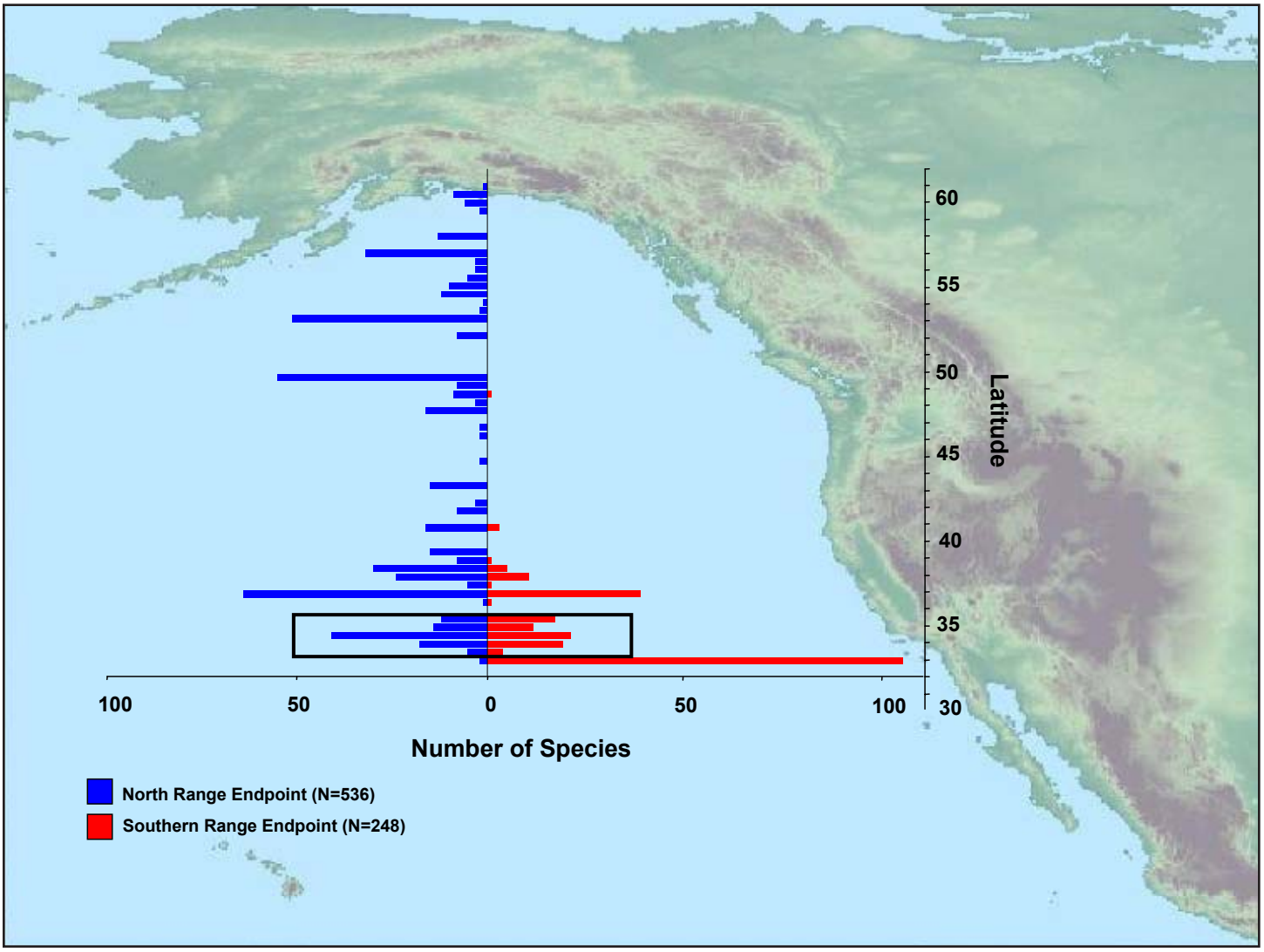

Figure 1.3.3. Latitudinal range endpoints for 539 species of marine benthic invertebrates.

biogeographic transition among members of this taxon. In contrast, Scorpaeniform fishes are distributed widely along the western coast of North America, from Baja California to the Bering Sea. A comprehensive analysis of the distribution of 500 species of marine fishes conducted by Horn and Allen (1978) also supports the results found here. The authors identify Point Conception as the most significant biogeographic boundary which could extend as far south as 30°S latitude. The authors note that Point Conception appears to be a more distinct boundary for southern species than northern species, which is consistent with results presented here.

Seabirds and Shorebirds

Distribution information used for this analysis was extracted from Peterson (1990), and included 132 shorebird and seabird species (Figue 1.3.5). Information on northern and southern range endpoints were summarized into 2° latitudinal bins. The resulting histogram shows small breaks in central and southern California. Central California is the northern endpoint for the distribution of four species (black-vented shearwater, least bittern, black storm-petrel, and clapper rail) and the southern endpoint for five species (glaucous gull, fork-tailed storm-petrel, Barrow's goldeneye, harlequin duck, and yellow-billed loon). While southern California is the northern endpoint for only three species (gull-billed tern, royal tern, and least storm-petrel), it is the southern endpoint for eight species (horned and red-necked grebes, mew gull, black scoter, common murre, pigeon guillemot, tufted puffin, and marbled murrelet). Overall, the distributions of most seabird and shorebird species found in the region of interest were wide ranging. Most of the northern range limits occurred in the Gulf of Alaska and Bering Sea, whereas most of the southern range limits occurred in Mexico. Although the coast of California does not present a significant biogeographic barrier for most seabirds and shorebirds, nearly ten percent of the species examined had a range terminus near southern California.

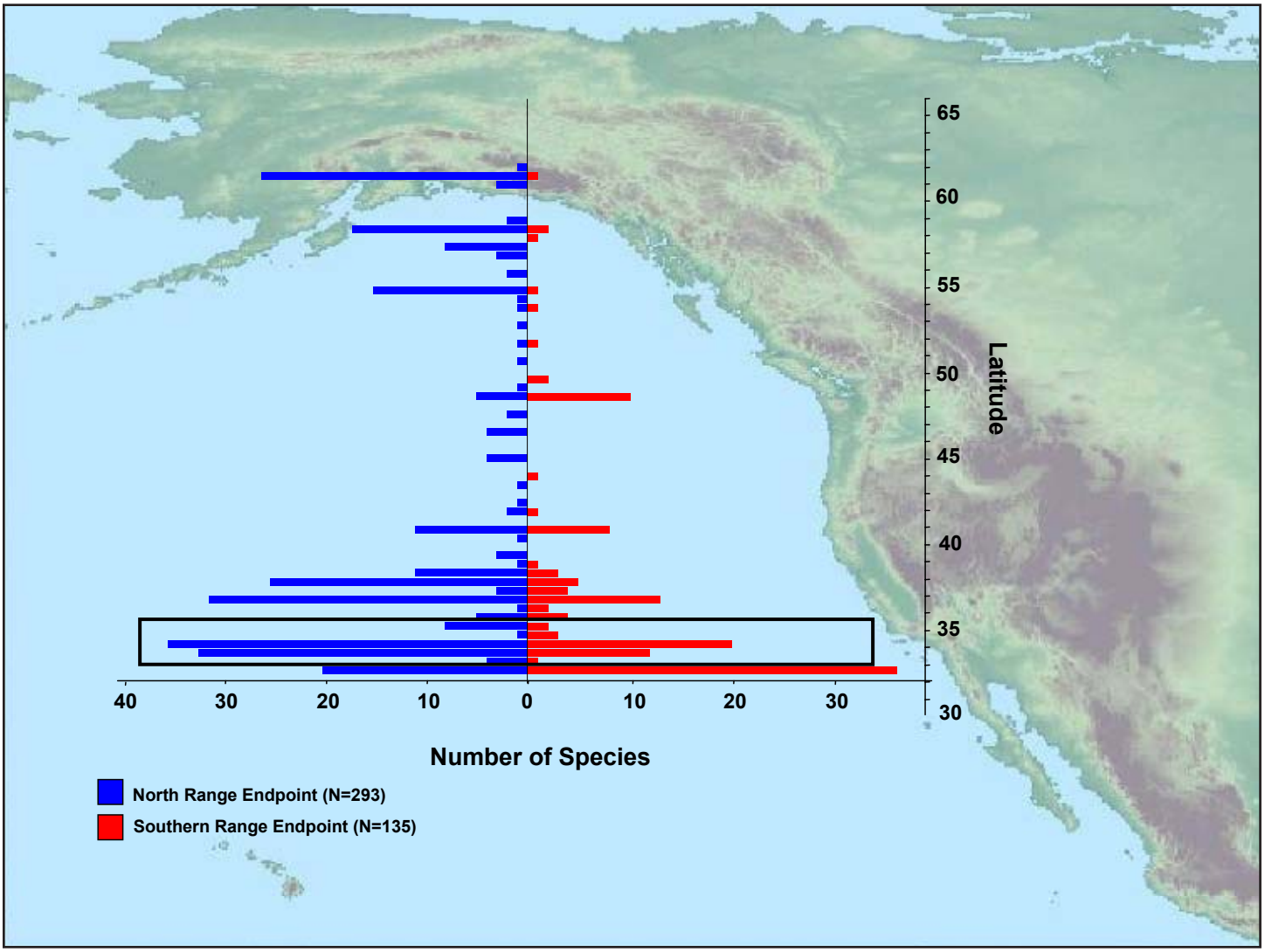

Figure 1.3.4. Latitudinal range endpoints for 294 species of marine fishes.

Marine Mammals

49 marine mammal species were included in this range endpoint analysis. Information about each species was obtained from Burt and Grossenheider (1976) and included the northern and southern range endpoints in 2° latitudinal bins (Figure 1.3.6). The most significant boundary in California occurs near Point Conception. A few delphinid species, including the melon-headed whale, pygmy killer whale, false killer whale, short-finned pilot whale, and striped dolphin are found primarily south of this promontory, while others such as the northern right whale dolphin, Dall's porpoise, harbor porpoise, Hubb's beaked whale, and Stejneger's beaked whale are found primarily north. This represents over twenty percent of the species examined in this study which is significant given that local oceanographic patterns and habitat features generally do not constrain the distributions of large marine mammals. The majority of marine mammals examined however, were widely distributed along the western coast of North America. Pinnipeds also exhibited wide distributions from Alaska to central or southern California and Baja California with no biogeographic breaks occurring in the region. Harbor seals are widespread in coastal habitats of the northern hemisphere. California sea lions are found from Vancouver Island to the southern tip of Baja California. Most of the population of Steller sea lions is in the Gulf of Alaska and the Bering Sea, but small populations are found along the coast as far south as central California. Northern elephant seals are distributed from the Aleutian Islands to Baja California. Although most of the worldwide population of northern fur seals is found on the Pribilof Islands, a small number of northern fur seals are found on Bogoslof Island in the southern Bering Sea, San Miguel Island off southern California, and the Farallon Islands off central California.

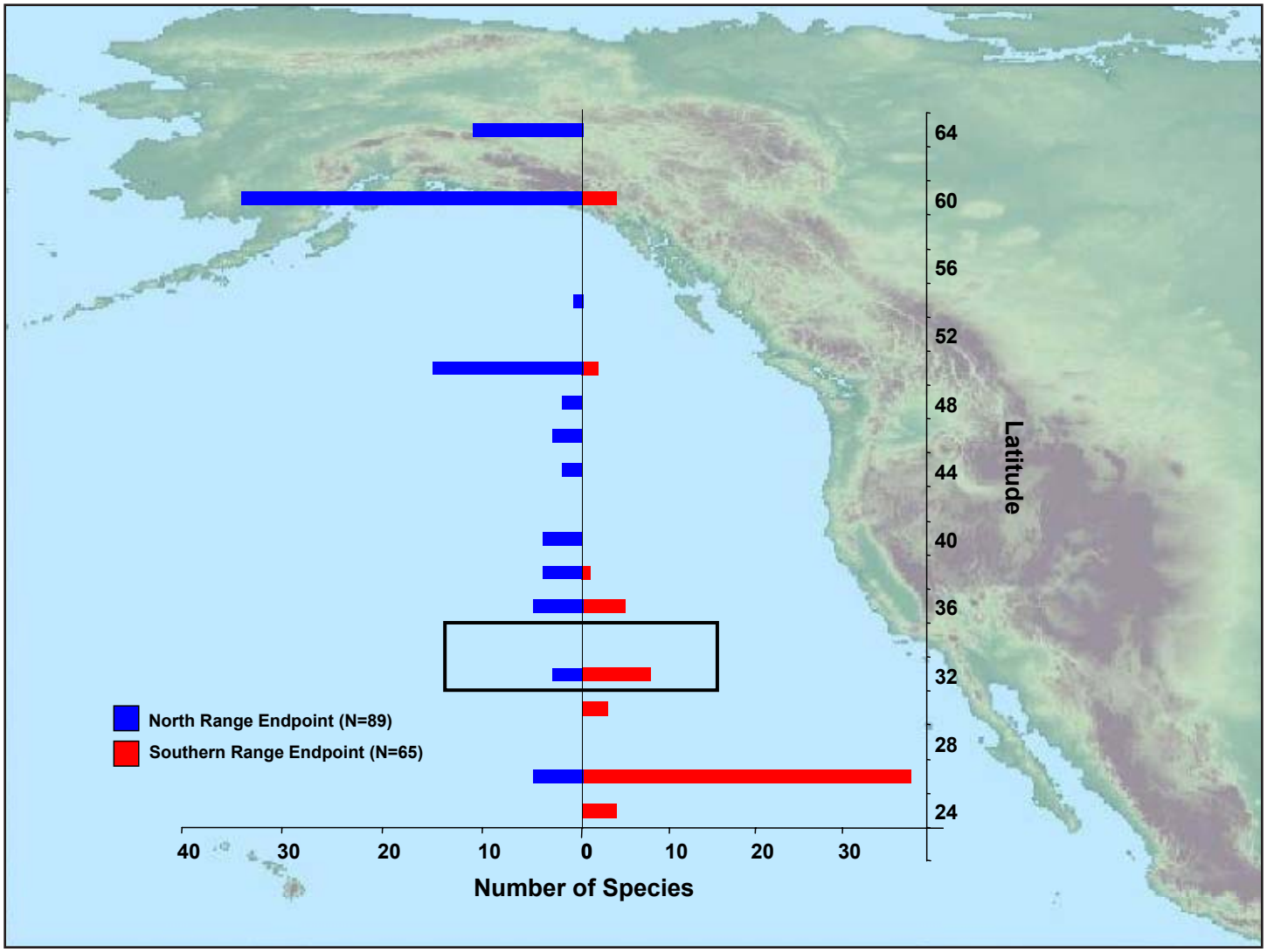

Figure 1.3.5. Latitudinal range endpoints for 132 shore and seabird species.

1.4 THE FOUR-STEP ASSESSMENT PROCESS

Species Selection

The initial step in the biogeographic assessment presented in the following chapters involved the identification of key species and the collection of relevant biological and physical data sets in the region of interest necessary to conduct spatial analyses. Recently, the state of California underwent a process to evaluate the region around the Channel Islands in order to determine which areas would be delineated as marine protected areas (MPA). One component of that process involved the identification of species whose distributions would be the biological focus of the decision. A working group was formed that developed a set of criteria to define species of interest around the Channel Islands. The list of species selected with these criteria includes: (1) species of economic and recreational importance, (2) keystone or dominant species, (3) candidate, proposed, or species listed under the Endangered Species Act, (4) species that have exhibited long-term or rapid declines in harvest and/or size frequencies, (5) habitat forming species, (6) indicator or sensitive species, and (7) important prey species. The list excludes species that are: (1) incidental, (2) at the edge of their ranges, or (3) highly migratory. The criteria by which the species were selected for the MPA effort were equally relevant for an analysis of the regional biogeography. However, the final species list for the biogeographic assessment was shortened, primarily for fish and invertebrates, due to the lack of sufficient spatial biological data.

Data Collection and Synthesis

Over 50 researchers along the west coast from federal and state agencies, non-governmental organizations, and academia were contacted in an effort to assemble all existing distributional data pertinent to the species selected above as well as their associated habitats. Once a data set was identified its utility was evaluated through exami-

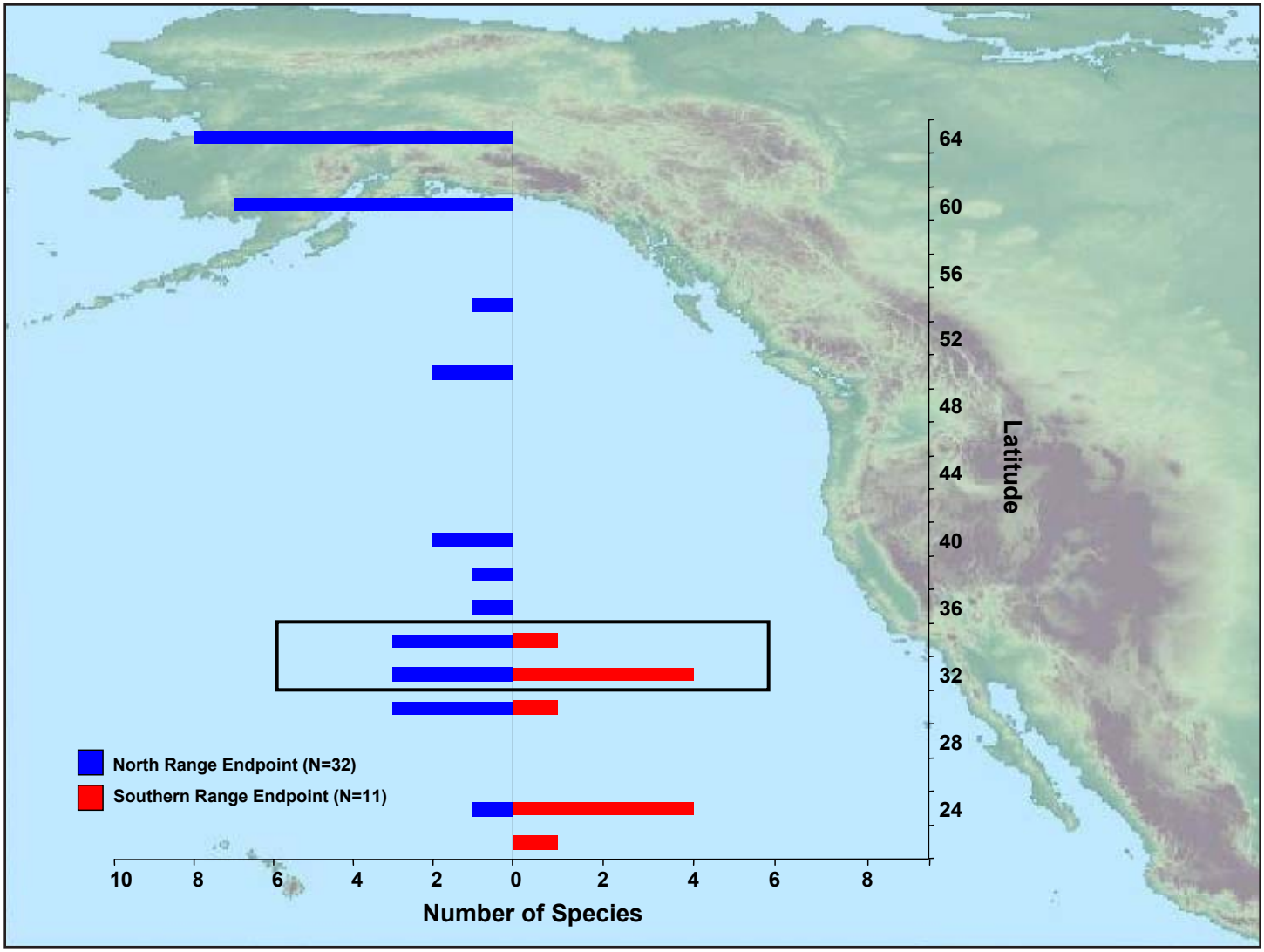

Figure 1.3.6. Latitudinal range endpoints for 49 marine mammal species.

nation of its spatial extent and quantity of information provided. As this study was dependent on pre-existing data rather than the collection of data specific to the questions asked, the type and quality of information collected was extremely variable from one data set to the next. Among the complexities of working with these inherently variable data were varying spatial and temporal coverages, as well as different methodologies employed in data collection. To the extent that differences precluded data sets from being combined and analyzed together, they were kept separate. Appendix B lists the data sets used in this assessment (as well as some that were identified, but not used) and the contact information for the data providers.

Broad-scale patterns were identified in the distribution of taxa based on species presence and absence, as well as abundance information where available. This step began by combining each unique data set into a common spatial framework within a Geographical Information System (GIS). An aggregate look across multiple species was conducted through examination of community metrics such as diversity and richness. In some cases, data were sufficient to perform clustering analyses to examine the co-occurrence of species at various locations. Patterns in the analyses conducted were then set in the context of the physical data layers (oceanography, bathymetry, and sediment). These layers were also utilized for modeling the potential distributions of specific invertebrates and fishes as existing data on individual species within those taxa was insufficient.

The next step in the process was the evaluation of the six boundary concepts with respect to resource distribution.

Metric Development

The choice of an appropriate metric for comparison of the different boundary concepts is a difficult one, and involves implicit value judgments. Since such judgments are policy decisions, and inherently beyond the scope of a biogeographic assessment, we have chosen to present three separate metrics along with a discussion of their biases and implied values. In each chapter, we present an absolute metric (count), a relative metric (density or mean), and the Optimal Area Index (OAI) for each boundary alternative. The absolute and relative metrics are provided because they are simple and intuitive. However, because these two metrics show biases for larger and smaller alternatives respectively, we have also chosen to present the OAI (explained below), which attempts to balance these two tendencies. None of these metrics is objectively better than another, and a thorough comparison of the boundary concepts will require consideration of all of them.

A fundamental distinction can be made between metrics which are based on absolute quantity and those based on relative quantity. Examples of absolute metrics include the total number of blue whale observations recorded in boundary Concept 5, or the total area of above average bird density falling within the current CINMS boundaries. Examples of relative metrics include the number of blue whale observations/km^2 recorded in boundary Concept 5, or the average bird density within the current CINMS boundaries. Although the difference in wording is subtle, under many circumstances the results of absolute and relative metrics can be completely opposite.

Consider a situation (illustrated in Figure 1.4.1) in which the area of greatest conservation value is concentrated in one location and that value declines with distance from this center. A set of hypothetical boundary concepts exist such that each boundary is centered on the location of highest conservation value, and each successively larger boundary encompasses the smaller. In this situation, absolute metrics will inherently favor the largest boundary. This is because, for absolute metrics, more is necessarily better (or at least no worse) when the smaller options are a subset of the larger ones. In our hypothetical example, relative metrics will inherently favor the smallest boundary. Since all boundaries are centered on the region of highest conservation value, expanding from the smallest can only add areas of relatively lower conservation value, thus reducing the magnitude of relative metrics such as means or densities. These relationships are illustrated in Figure 1.4.2.

For many of the species and community metrics discussed in this assessment, the hypothetical example above is an apt description of the situation. The current boundary of the CINMS was chosen in part because for many species it encompasses an area of optimal habitat. The smaller boundary concepts are also generally subsets of the larger concepts, with all options encompassing the current boundaries. To the extent that each species or community metric matches the hypothetical situation, absolute metrics will be biased toward the larger boundary concepts and relative metrics will favor the smaller.

Because of the inherent biases of absolute and relative metrics, we have included a third metric which attempts to provide a more balanced gauge of the relative merits of different boundary concepts. This third metric (the OAI) represents the relative increase in some measure of ecological value, divided by the relative increase in area compared to the current boundaries. The OAI is calculated using the formula:

$$OAI=(B_1-B_0/B_0)/(A_1-A_0/A_0)$$

where B_1 and B_0 refer to the value of the ecological metric (e.g. sightings, diversity, richness, etc.) within the boundary concept and the current boundaries respectively, and A_1 and A_0 are the respective areas. In the OAI, the terms representing the difference in ecological value (numerator) and the difference in area (denominator) are both calculated relative to the current boundaries. This provides some balance against the previously discussed biases, but may not eliminate them entirely.

Maps and spatial metrics of the boundary concepts evaluated using the above metrics are provided in Figure 1.1.2. After evaluating the six boundary concepts provided by the sanctuary, the data was further examined to determine if areas of high biological significance within the study region were absent from those options but should be considered as candidate regions for incorporation.

Analyses Review

All analyses completed as part of the biogeographic assessment were reviewed. All data providers, together with others familiar with the data sets, and selected members of the CINMS Sanctuary Advisory Council, were consulted to obtain consensus on the analytical methodology utilized and to ensure accurate interpretation of the resulting patterns.

1.5 ASSESSMENT OUTLINE

This assessment begins with a discussion of the physical setting (Ch. 2). The study area is described in this section in terms of the physical environment (geology, climate and meteorology, physical oceanography). Included in this chapter is a discussion of regional sea surface temperature patterns, chlorophyll, currents, and bathymetry as they are related to the boundary concepts. This places into context the four subsequent analytical chapters: marine invertebrates (Ch. 3), fishes (Ch. 4), birds (Ch. 5), and marine mammals (Ch. 6). Where data was sufficient, each of these chapters includes an analysis of community structure as well as a look at the individual species identified by the sanctuary as being of high importance. The marine mammal chapter is further refined with a section on pinnipeds and sea otters and another on cetaceans. Each chapter includes four major sections. The first section describes in detail the data and methodology used in the analysis of that particular taxa. The second includes an analysis of broad-scale patterns looking over the entire range for which data was available in the given data set. Following this, the focus is on the study area and the boundary concepts. Finally, a summary section discuses the resulting patterns uncovered in the analyses. Chapter 7, the integration, summarizes all the results and looks across all taxa for consistent patterns and contains an evaluation of how the different boundary concepts compare.

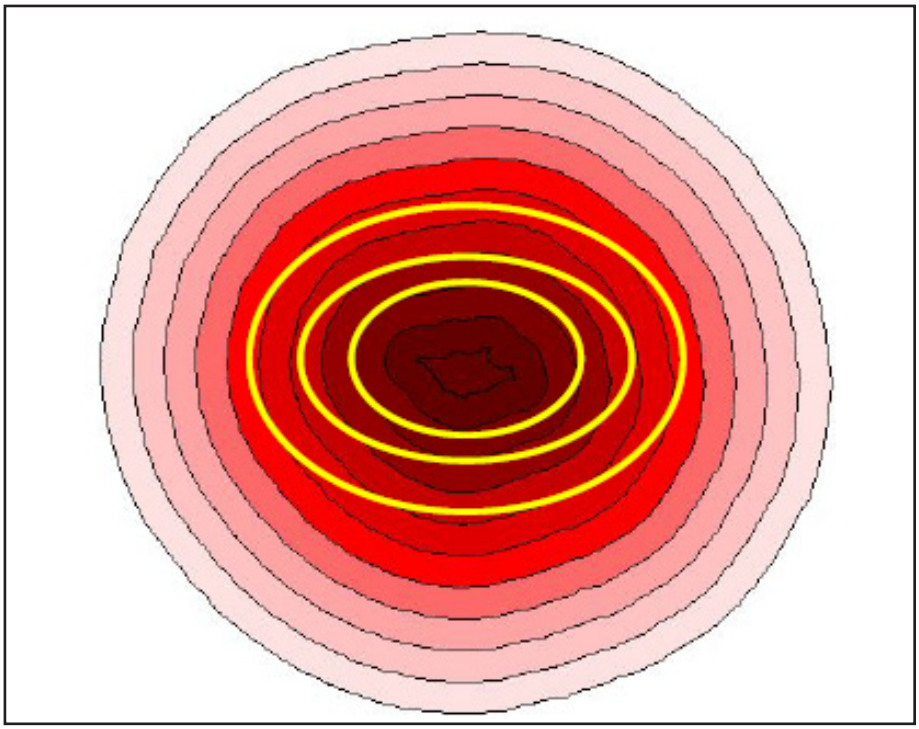

Figure 1.4.1. A hypothetical set of three boundary concepts (yellow lines), and the ecological value (red circles, with darker colors representing greater values) of the area contained within them.

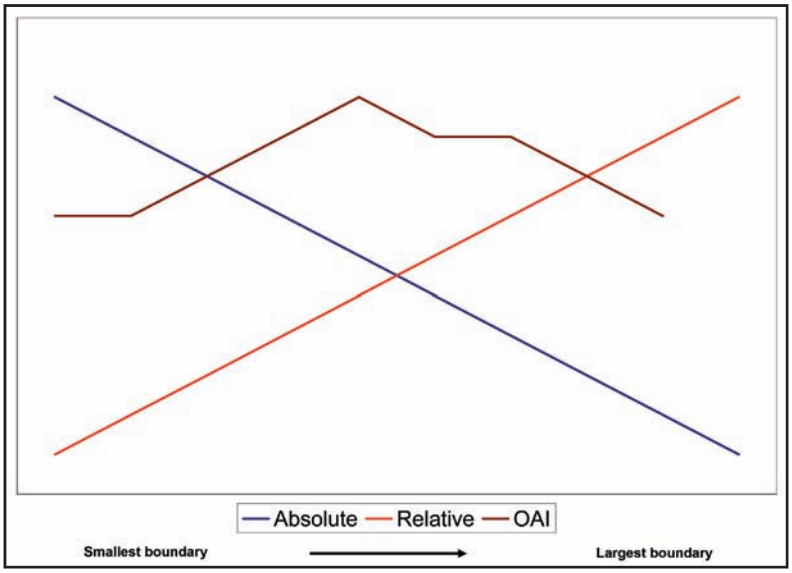

Figure 1.4.2. Trend in values of absolute and relative metrics and the OAI (rescaled for display) for the hypothetical example shown in Figure 1.4.1.

LITERATURE CITED

Airamé, S., J.E. Dugan, K.D. Lafferty, H. Leslie, D.A. McArdle and R.R. Warner. 2003. Applying ecological criteria to marine reserve design: a case study from the California Channel Islands. Ecological Applications 13(1):S170-S184.

Allen, M.J. 1982a. Functional structure of soft-bottom fish communities of the southern California shelf. Ph.D. Dissertation. University of California, San Diego, California. 577 pp.

Allen, 1982b. Large-scale considerations in studies of resource partitioning. pp. 185-189. In: G. M. Cailliet and C. A. Simenstad (Eds.), Gutshop '81, Fish food habits studies. Washington Sea Grant, University of Washington, Seattle, WA.

Allen, M. J. In press. Continental shelf and upper slope. In: L. G. Allen, M. H. Horn, and D.J. Pondella, II (Eds.), Ecology of marine fishes: California and Baja California. University of California Press, Berkeley, CA.

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. NOAA Technical Report. NMFS 66. 151 pp.

Allen, M.J., R.W. Smith, E.T. Jarvis, V. Raco-Rands, B. Bernstein, and K. Herbinson. 2004. Temporal trends in southern California coastal fish populations relative to 30-year trends in oceanic conditions. pp. 264-285 In: S. B. Weisberg and D. Elmore (Eds.), Southern California Coastal Water Research Project Biennial Report 2003-2004, Southern California Coastal Water Research Project, Westminster, CA.

Andrewartha, H.G., and L.C. Birch. 1954. The distribution and abundance of animals. University of Chicago Press, Chicago, IL.

Briggs, J.C. 1974. Marine Zoogeography. McGraw-Hill Book Company. New York, NY. 475 pp.

Briggs, J.C. 1995. Global biogeography. Elsevier, New York, NY. 454 pp.

Burt, W.H., and R.P. Grossenheider. 1976. A field guide to the mammals. 3d ed. Houghton Mifflin Co, Boston, MA. 289 pp.

Dawson, M.N. 2001. Phylogeography in coastal marine animals: a solution from California? Journal of Biology 28:723-736.

Eckert, G. Unpublished data. University of Alaska.

Eschmeyer, W.N., E.S. Herald, and H. Hammann. 1983. A field guide to Pacific coast fishes of North America. Houghton Mifflin Company, Boston, MA. 336 pp.

Hayden, B.P., and R. Dolan. 1976. Coastal marine fauna and marine climates of the Americas. Journal of Biology 3:71-81.

Hedgpeth, J.W. 1957. Classification of marine environments. pp: 17-27. In: Hedgpeth, J.W. [Ed.] Treatise on marine ecology and paleoecology. Geological Society of America Memoranda 67(1).

Horn, M.H, and L.G. Allen. 1978. A distributional analysis of California coastal marine fishes. Journal of Biology 5:23-42.

Hubbs, C.L. 1949. Changes in the fish fauna of western North America correlated with changes in ocean temperature. Sears Foundation Journal of Marine Research 7(3):459-487.

McGinnis, M.V. 2000. A Recommended Study Area for the CINMS Management Planning Process: Ecological Linkages in the Marine Ecology from Point Sal to Point Mugu, including the Marine Sanctuary. Prepared for Channel Islands National Marine Sanctuary by the University of Claifornia, Santa Barbara. 50 pp.
:
McGowan, J.A. 1971. Oceanic biogeography of the Pacific. pp: 3-74, In: B.M. Funnell and W. R. Riedel (Eds.), The micropaleontology of oceans. Cambridge University Press, Cambridge, England.

Newell, I.M. 1948. Marine molluscan provinces of western north America: a critique and a new analysis. pp: 155-166, In: Proceedings of the American Philosophical Society 92:155-166.

National Oceanic and Atmospheric Administration (NOAA). 1990. West Coast of North America strategic assessment: Data atlas, invertebrate and fish volume. Prepublication edition. Strategic Assessments Branch, National Ocean Service, NOAA. Rockville, MD. 112 pp.

NOAA National Centers for Coastal Ocean Science (NCCOS). 2003. A biogeographic assessment off north/central California: To support the joint management plan review for Cordell Bank, Gulf of the Farallones, and Monterey Bay National Marine Sanctuaries: Phase 1 - Marine fishes, birds, and mammals. Silver Spring, MD. 145 pp.

Peterson, R.T. 1990. A field guide to western birds, 3rd Ed. Houghton Mifflin Company, New York, NY.

Roy, K.,D. Jablonski, and J. W. Valentine. 1994. Eastern Pacific molluscan provinces and latitudinal diversity gradient: No evidence for “Rapoport’s Rule.” pp: 8871-8874. In: Proceedings of the National Academy of Science 91.

Valentine, J.W. 1966. Numerical analysis of marine molluscan ranges on the extratropical northeaster Pacific shelf. Limnology and Oceanography 11: 198-211.