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Negotiating ecology: Marine bioregions and the destruction of the Southern California Bight

Michael Vincent McGinnis*

Bioregional Planning Associates, 3865 Sterrett Avenue, Santa Barbara, California 93110, USA

Abstract

Bioregional studies tend to focus on landscapes and associated cultural and biological diversity. This essay provides a general overview of the ecology of the Southern California Bight (SCB), which is the coastal marine bioregion of southern California. The bioregion is considered one of the most threatened 'hot spots' for biodiversity in the world. The SCB includes the Channel Islands National Marine Sanctuary, the Channel Islands National Park, and a designated 'biosphere reserve' of the United Nations Man and the Biosphere Program. The essay describes the destruction of southern California's coastal watersheds and wetlands, and provides a summary of the significant decline in ecological productivity of the marine bioregion. Despite the decline in general marine ecosystem integrity, there has been no large-scale planning effort that focuses on the entire coastal marine bioregion. With this in mind, the essay provides an overview of recent policy initiatives that call for the establishment of Marine Protected Areas or MPAs to protect marine ecosystems. Without a new institutional approach to the entire bioregion the future of the coastal marine ecosystems of the system is rather dim. With this in mind, the author recommends a number of institutional changes that support large-scale bioregional planning.

1. Bioregionalism and Coastal Marine Ecosystems

In January 1995, machete-wielding locals protested the creation of the Galapagos Marine Resources Reserve, and blocked the entrance to the Darwin Station in Puerto Ayora, the headquarters of the National Park. The protesters held several workers of

* Corresponding author. Tel.: +1 805 682 5510.
E-mail address: mcginnis9@cox.net.

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the National Park captive for four days, and harassed marine scientists. Later in 1997, 20 masked men on the Island of Isabela attacked National Park personnel, local officials, and marine scientists of the area.

This is becoming a common scene throughout the world—unsustainable use of coastal marine life continues to have dramatic impact on maritime cultures and coastal marine ecosystems [27,32]. Marine scientists document the general decline in primary and secondary levels of ecological productivity in coastal marine ecosystems across the world. For example, Jeremy Jackson et al. [12] describe the history of the collapse of kelp and other coastal marine ecosystems off southern California. 'Overfishing and ecological extinction', according to Jackson et al. [12], 'predate and precondition modern ecological investigations and the collapse of marine ecosystems in recent times, raising the possibility that many more marine ecosystems may be vulnerable to collapse in the near future'.

In general, bioregional studies focus on terrestrial and aquatic ecosystems, such as a watershed or river basin, and associated cultural and biological diversity [17]. The focus on bioregional *landscapes* is ironic given the fact that the planet is a blue planet—a planet of swirling ocean currents, diverse seas, bays and associated marine life.

This essay describes the nebulous boundaries of the sea. Coastal marine bioregions include ecological linkages, connections and relationships between habitats, oceanography (e.g. currents), biology and climate [14]. Coastal marine bioregions often transcend political, administrative and economic boundaries or jurisdictions. In the eastern Pacific, for example, hydrographic circulation patterns and climate events, such as El Niño, span scales of up to thousands of kilometers [11]. The dispersal and migration of marine organisms can span huge geographical distances, such as the migration of gray whales along the California coast, the flight of the arctic tern, or the return of the wild southern steelhead salmon to spawn in a creek of a coastal watershed.

This essay first describes the historical inhabitation of this coastal marine bioregion. Recognizing the importance of the first human inhabitants of a bioregion is one first step toward understanding the natural history and ecology of a bioregion. The first inhabitants, the diverse coastal tribes of the Chumash people, shaped the general ecology of the region. The Chumash people lived in villages along the south-central California coast from the present day sites of Malibu Point to Morro Bay and extended to the northern Channel Islands. The varied maritime culture was diverse and depended on the rich array of animals and plants.

Second, the essay provides a general overview of the ecology of the Southern California Bight. This coastal marine bioregion is located between Point Sal (in central California) and Punta Banda (south of Ensenada, Baja California, Mexico) [8]. The coastal and marine ecosystems of the Southern California Bight (SCB) have been extensively studied [8]. The coastal marine area is considered by state and federal resource agencies and non-government organizations to be a distinct bioregion of California [4]. There are 24 major watersheds and 28 estuaries and wetlands that exist within the 32,000 square km of the SCB [10,30]. The marine bioregion includes the Channel Islands National Marine Sanctuary (CINMS), which is part of the National Marine Sanctuaries Program (NMSP), and the Channel Islands National Park. The northern Channel Islands are also a designated 'biosphere reserve' of the United Nations Man and the Biosphere Program.

Third, the essay describes the destruction of southern California's coastal watersheds and associated coastal wetlands, and provides a summary of the significant decline in

marine ecological productivity of the SCB. Marine scientists have shown a dramatic decline in primary and secondary levels of ecological productivity in the coastal marine bioregion of southern California [19,22].

Despite the decline in biodiversity and loss of coastal marine habitats, there has been no large-scale planning effort that focuses on the entire coastal marine bioregion. With this in mind, the essay provides an overview of recent policy initiatives that call for the establishment of Marine Protected Areas or MPAs [15]. While interdisciplinary marine science has come of age, some marine managers have yet to accept the best available scientific information that supports the creation of large networks of MPAs that can protect marine ecosystems. One reason for this is that the prevailing institutions that regulate marine resource use, such as fisheries, are 'captured' by fishery special interests [26].

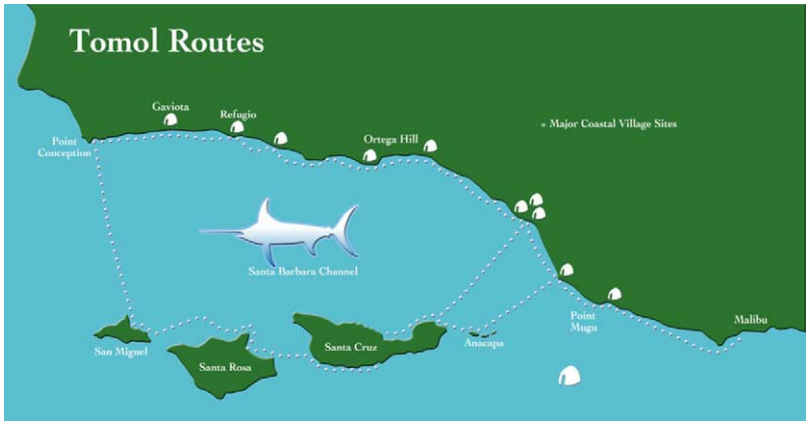
Without a new institutional approach to the entire bioregion the future of the coastal marine ecosystems of the system is rather dim. The bioregion remains one of the most threatened 'hot spots' for biodiversity in the world [20,23]. With this in mind, I recommend a number of institutional changes that support large-scale ecosystem management and planning.

2. The First Inhabitants of the Coastal Marine Bioregion

Evidence of tribal Chumash village sites and tomol routes show an intimate relationship with the culture, sea and northern Channel Islands [21]. The inhabitation of the region by the Chumash culture reflected the relative hydrological area of the south-central California. Indeed, tribal inhabitation of California was reflected in the language spoken; kinship relationships and the boundaries of aboriginal society often reflected the soft boundaries of a watershed or bioregion.

Map 1 shows the villages and tomol routes within the greater Chumash bioregion.

The abundance of prehistoric Chumash artifacts found in the marine environment have helped archaeologists piece together Chumash trade networks, fishing practices



Map. 1. Source: McGinnis [21].

and submerged village sites. The diverse Chumash people spoke different but related languages in distinct but interdependent parts of the bioregion. The people also were heavily dependent on a healthy marine environment; the marine component of the Chumash diet consisted of over 150 types of marine fishes as well as a variety of shellfish including crabs, lobsters, mussels, abalone, clams, oysters, chitons, and other gastropods. Shellfish were essential to the Chumash economy and material culture. In fact, the Chumash produced the majority of shell bead money used by indigenous peoples throughout southern California.

Portions of the northern Channel Islands were likely sites of Chumash villages, and are now submerged by changes in sea level. Thousands of years ago the sea level was at least 150 feet lower than it is today and the northern Channel Islands were joined as one island. Some submerged artifacts may have been deliberately deposited in the water during religious ceremonies, washed to the sea from shore, or been deposited in the water through cliff erosion. Recently discovered paleontological remains have also contributed to the rich record of the coastal area. In 1994, for example, a relatively complete pygmy mammoth was discovered on a coastal bluff on the north shore of Santa Rosa Island. This discovery represents the most complete pygmy mammoth discovered in the world to date. Early human remains of a woman ('Arlington Springs Woman') were discovered at Arlington Canyon on Santa Rosa Island, dating back to the end of the Pleistocene, approximately 13,000 years ago. This Channel Islands' site represents the oldest human yet discovered in North America.

Descendants of the Chumash consider the northern Channel Islands a special place, still occasionally paddling these waters in tomols or special wooden canoes. The first tomol to be owned by the Chumash people since the 1880s is 'Elye'wun, which was built by the Chumash community in 1996–1997 under the leadership of the Chumash Maritime Association. The building of 'Elye'wun (i.e. swordfish) and the crossing to Santa Cruz Island is a manifestation of a new effort by the Chumash people to reconnect and restore their relationship to the sea and northern Channel Islands.

Abalone was a staple of the Chumash diet. White abalone is a marine snail, a deep-water species found between 80 and 200 feet on rocky reefs from Point Conception to Punta Abreojos in Baja California, Mexico. During the early 1970s, the Channel Islands were home to 1000–5000 white abalone per acre. Highly prized for their tender white meat, white abalone were harvested in an intense commercial and recreational fishery that developed during the 1970s, then quickly peaked and crashed as the abalone became increasingly scarce. The fishery for white abalone closed in 1996. In the 1990s, less than one white abalone per acre could be found in surveys conducted by federal and state biologists. The rarity of this species within its historical center of abundance prompted the National Marine Fisheries Service (NMFS) to list it as a candidate species under the Endangered Species Act in 1997. In May 2001, the white abalone became the first marine invertebrate to receive federal protection as an endangered species in the bioregion.

The plight of the white abalone is a symptom of a much larger-scale threat to the coastal marine ecosystems of the bioregion. As this essay shows below, there are signs that coastal marine ecosystems are no longer healthy; some species and habitats may be on the verge of biological collapse.

3. The Yantra principle: identifying the boundaries of coastal marine bioregions

Today, as we try to recover a sense of place and community, we recognize the urgent need to re-build a bridge to our historic maritime culture and to the other creatures of the bioregion. Many of habitats and species of the bioregion are either threatened or endangered.

The Chumash people adapted to significant environmental change in the bioregion by developing new ways of living with the animals, plants and insects [21]. But adapting to a changing ecological context has been made more difficult in a system that includes large-scale industrialization of use of coastal marine resources of southern California. Fifty years ago in *The Log from the Sea of Cortez* the noted California author John Steinbeck [31] wrote:

> "The pieces must stick within their pattern or the whole thing collapses and the design is gone. We wonder whether in the present pattern the pieces are not straining to fall out of line; whether the paradoxes of our times are not finally mounting to a conclusion of ridiculousness that will make the whole structure collapse."

The question is whether or not human beings can develop the appropriate institutions that can support cultural adaptation to a significantly disturbed natural world.

One key to cultural adaptation is to recognize the dynamic nature of coastal marine bioregions. The 'boundaries' of coastal marine ecosystems are not hard but soft and complex. Coastal marine bioregions are influenced by ecological relationships between the currents, habitats, the winds, the climate, human activities and a range of other natural factors [14]. Agardy [2] writes:

> "It is notoriously difficult to attach boundary conditions to marine ecological processes, just as it is difficult to bind the impacts that affect these processes. In essence, it is impossible to 'fence in' living marine resources or the critical ecological processes that support them, just as it is impossible to 'fence out' the degradation of ocean environments caused by land-based sources of pollution, changes in hydrology, or ecological disruptions occurring in areas adjacent or linked to a protected area."

The boundaries of the sea are analogous to the notion of *Sri yantra*. The *yantra* is a ritual object of Nepal, which represents the nucleus of the visible, and knowable, a linked diagram of lines that reflect particular energy sources. There are different kinds of *yantras*, such as the *Sri Yantra* or Great Yantra. Other lesser *yantras (Om yantra, Kali yantra*) are segments out of the great embracing *Sri Yantra*. The notion of *yantra* serves as analogy for the substance and energy of earth—the source of life, the connecting energy source that unites all earthly entities. The earth includes many lesser 'yantras'. The sea can be considered a lesser yantra of the earth. The oceanography, biology and climate influence wildlife of the sea. For example, water temperature and currents, pollution from the coastal mainland, and the presence of other life forms like urchins and their predators the southern sea otter influence the abundance of kelp forests off of southern California's coast. Each animal and habitat is connected to the greater yantra of the earth.

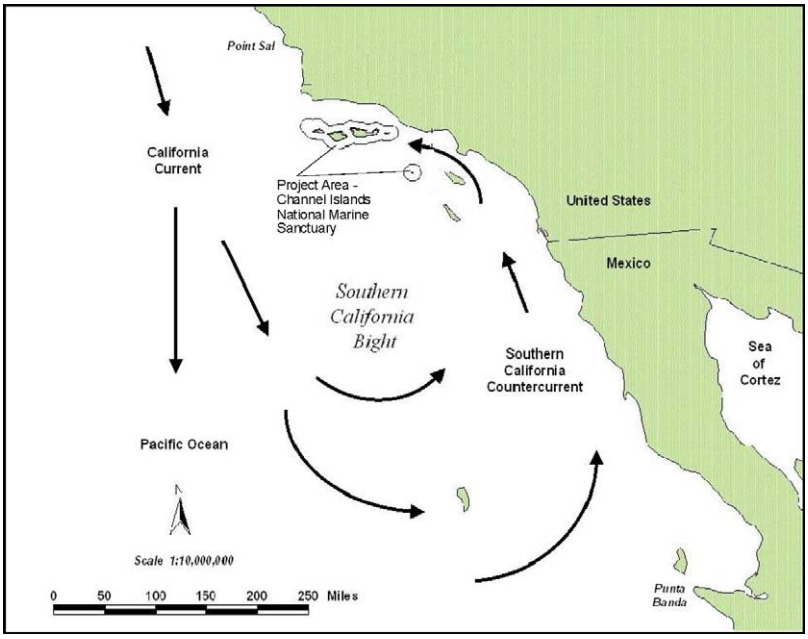
Marine scientists acknowledge that marine ecosystem boundaries are difficult to define (and manage) because of the general lack of interdisciplinary marine scientific

information [14]. There exists a mismatch between scales of atmospheric and oceanographic processes and the spatial and temporal dimensions of biological studies and research. McGowan et al. ([22] p. 210) note, "Much of the biological, observational evidence is disconnected spatially and often discontinuous temporally… we must accept less than ideal data in our attempt to understand what is happening." Marine scientists have yet to link information on oceanographic regimes with information on habitat distribution and marine biodiversity. Marine scientists tend to focus on the distribution and abundance of marine species and habitats; we know very little about the function, processes and structures of marine systems [7].

Given scientific uncertainties, we cannot control or 'manage' the ecological relationships that exist within coastal marine ecosystems. Ultimately, bioregionalism requires some type of social and institutional innovation that can foster cultural adaptation and ecological sustainability [17]. Coastal marine bioregions often transcend political, administrative and economic jurisdictions. Human beings cannot control natural factors. Human beings can only control human behavior (after Ludwig et al. [13]).

4. Adapting to the changing ecology of the southern California Bight

The SCB is a unique marine 'ecotone' or transition area that combines warmer and colder-water oceanographic provinces. Within the SCB, Map 2 shows that the Santa



Map. 2.

Barbara Channel includes patterns of warm, saline water from the Southern California Countercurrent and the colder water from the California Current [11].

The 'mixing' of oceanographic currents produces one of the world's hot spots for coastal marine life; the marine area of the northern Channel Islands should be considered 'the Galapagos of the eastern Pacific' due to the region's biodiversity.

Rocky intertidal areas in the SCB probably include more than 220 plant species and up to 610 invertebrate species [8]. In the SCB, 492 species of algae and four species of seagrasses are known to occur out of the 637 species described for the entire coast of California. Of these 492 species, 59 are green algae, 86 are brown algae, and 347 are red algae.

Giant kelp is the most important marine habitat of the SCB, and was at one time common at depths between 3 and 30 m. This highly productive plant provides food, attachment sites, and shelter for marine life. Kelp contributes substantially to the primary productivity of coastal waters. Giant kelp is especially important to juvenile fishes as the dense thicket of kelp in the water column provides for their nursery grounds.

About 481 species of fish inhabit the SCB [8]. About 30% of the species and 40% of fish families in the SCB depend on kelp habitat.

Eelgrass beds are also important for primary production, nutrient cycling, and substrate stabilization. Like kelp and surfgrass, eelgrass beds provide food and habitat for a diverse assemblage of plants and animals. At the Channel Islands, a total of 278 species were identified and associated with eelgrass beds, excluding infaunal species.

In addition, over 195 species of birds use open water, shore, or island habitats in the SCB [8]. The bioregion is located along the Pacific Flyway, a major migratory route for birds, and acts as a stopover during both north (April–May) and south (September–December) migrations. The habitats of the SCB provide breeding, nesting, and feeding sites for many species and large numbers of seabirds, including many federally and state listed endangered and threatened species.

A range of natural and human factors influences coastal marine bioregions. Figure 1 depicts the natural history of regulatory change and major events in marine ecology for the SCB.

The natural history of the coastal marine bioregion shows that major ecological events were often followed by policy innovation. For example, the oil spill of 1969 in the Santa Barbara Channel was followed by the development of 14 new federal environmental laws in the US, including the National Environmental Policy Act.

Because of the collapse of the sardine *fishery* off California in 1949 marine scientists formed the California Cooperative Oceanic Fisheries Investigations (CalCOFI) to study the general ecology of the Bight. The organization hosts an annual conference, publishes data reports and a scientific journal, and maintains a publicly accessible data server. CalCOFI organizes cruises to measure the physical and chemical properties of the California Current System, and census populations of organisms from phytoplankton to avifauna. This is the foremost observational oceanography program in the US Members of CalCOFI and other marine scientists collect information on the Bight's temperature, salinity, oxygen, water masses and currents, nutrients, primary production, phyto- and zooplankton biomass and biodiversity, meteorological observations, distribution and abundance of fish eggs and larvae, marine birds and mammals. There are a number of other interdisciplinary studies that are focusing on the relationships between oceanography

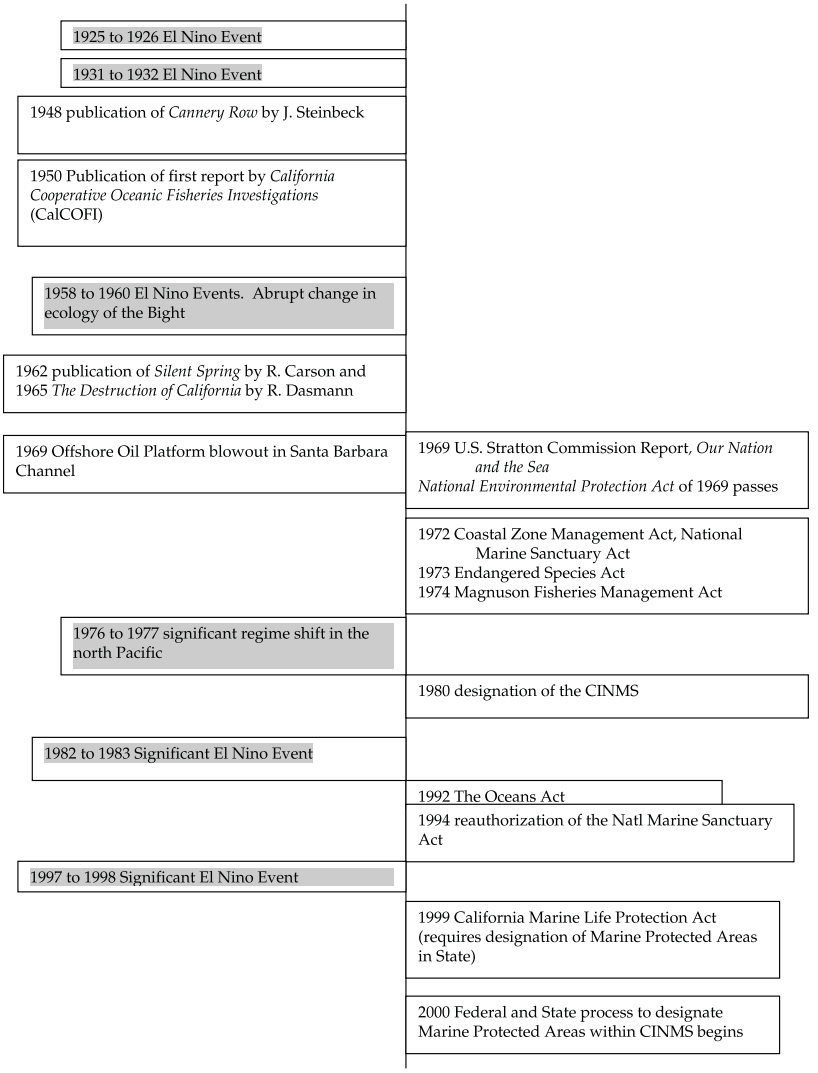


Fig. 1. Time line of key events in the Southern California bight, 1925–2000.

and biology, terrestrial inputs and nearshore marine habitats, and the abundance and distribution of marine life [24].

A careful examination of the scientific information from CalCOFI and other marine scientists shows that the ‘patterns’ of the Bight are changing; the ecological ‘pieces’ of the bioregion ‘are straining to fall out of line’. After 1980, new global markets for marine resources of the region emerged. Coastal development destroyed the wetlands of the region and the ‘nurseries of the sea’. There is also evidence of climate change within the marine system—sea temperature has risen, and sea levels are rising.

4.1. The Northern Channel Islands

An ecological core to the bioregion is the northern Channel Islands, which was designated as a national marine sanctuary in 1980 [24]. Map 3 shows the Channel Islands National Marine Sanctuary (CINMS), which encompasses 1252 square nautical miles of nearshore and offshore waters surrounding the islands of Santa Cruz, Santa Barbara, Anacapa, San Miguel and Santa Rosa [24].

Four government agencies have management jurisdiction over this marine area, including the California Department of Fish and Game (CDFG) (jurisdiction from 0 to 3 miles offshore), the National Marine Fisheries Service (3–6 miles offshore), the National Marine Sanctuaries Program (0–6 miles offshore), and the National Park Service (the islands to one mile offshore). A number of other federal agencies and departments are also involved in ocean and coastal management, including the US Department of Defense, which uses part of the Channel Islands for weapons testing [24]. These administrative jurisdictions have competing or conflicting mandates and constituencies; there is no agreed upon regional governmental unit that oversees the entire coastal marine system. The system of governance remains diffused, decentralized, fragmented and contentious.

The CINMS includes forests of giant kelp, and is home to numerous populations of fish and invertebrates [24]. At least 27 species of whales and dolphins have been sighted in the CINMS and about 18 species are seen regularly and are considered ‘residents’. The *largest* concentration of blue whales in the world can be found within the area. The CINMS lies on the migratory pathway of the California gray whale and other large baleen and toothed whales. Over 60 species of marine birds may be using sanctuary waters to varying degrees as nesting and feeding habitat, for wintering, and /or as migratory or staging areas.

Map. 3. The Channel Islands National Marine Sanctuary. Source: NOAA [24].

Of the 16 resident species of marine birds in the SCB, eleven breed in the CINMS. San Miguel Island supports the most numerous and diverse avifauna in the CINMS, with nine species having established colonies. Santa Barbara Island has several nationally and internationally significant seabird nesting areas, including the largest nesting Xantus' murrelet colony and the only nesting site in the United States of black storm-petrels. The brown pelican, a listed endangered species, maintains its only permanent rookery in California on Anacapa Island.

Because of the species richness and unique habitats of this marine system, this marine area received international recognition by the United Nations (UN) as one of the world's biosphere reserves. It is important to note, however, that the UN designation has no impact on the protection of marine life. Unlike World Heritage Designation by the UN, the designation of the area as a biosphere reserve has not led large-scale protection of the northern Channel Islands. There has been little if any sign of the role of UN in management or planning for this coastal marine bioregion. More importantly, this marine area is not a true 'sanctuary' for marine life; only a small percentage of the entire CINMS is protected from human use, e.g. fishing.

4.2. The rhetoric of ecosystem-based protection

In accordance to the National Marine Sanctuary Act, the priority goal of marine sanctuary management is to 'maintain, restore, enhance, living resources by providing places for species that depend on marine areas to survive and propagate' (The National Marine Sanctuary Act 16 U.S.C. 1431 *ET. SEQ.*, Sec. 301(b)(5)(9)). The National Marine Sanctuary Program (NMSP) emphasizes the importance of marine biodiversity conservation from an 'ecosystem-based approach'. According to the NMSP, "The [program] expands our nation's long history of protecting special areas on land to embrace the seas. It brings an ecosystem approach to marine environmental protection and asks us to adopt a new ethic of marine stewardship, but perhaps most of all, it challenges us to work together to find creative solutions to the problems facing our oceans and coasts."[1] The NMSP defines ecosystem management as a process that "should protect and restore ecological components, functions and structures according to socially defined values and scientific information, in an integrated, holistic manner." Moreover, the use of marine resources within a sanctuary must be 'compatible' with the goal of protection of biodiversity. The NMSP states:

> "The National Marine Sanctuaries Act of 1972 (NMSA) authorizes the Secretary of Commerce to designate and manage areas of the marine environment with nationally significant aesthetic, ecological, historical, or recreational values as National Marine Sanctuaries. The *primary objective of this law is to protect marine resources, such as coral reefs, sunken historical vessels or unique habitats, while facilitating all* '*compatible*' *public and private uses* of those resources [*my emphasis*].[2]"

[1] http://www.sanctuaries.nos.noaa.gov/natprogram/natprogram.html
[2] http://www.legislative.noaa.gov/sanct.html

Marine ecosystem management implies the protection of the various elements of the food web—those that are consumed and those species and habitats that are not consumed that are essential to the reproduction, growth, and survival of marine life. Long-term trends in seawater temperature, the abundance and distribution of indicator species, such as birds or mammals, or important habitats, such as kelp and eelgrass beds, can provide information on the general health and integrity of the marine ecosystem. Marine ecosystems must retain the ability to deal with outside interference, and if necessary, regenerate in the event of regime shifts and ecological disturbance, such as warming of sea temperature during climate-related events or fishing activities.

Despite the intent of the Sanctuary Act the scientific evidence shows that the habitats and marine life of the area have not been protected nor has government adopted an ecosystem-based approach to protect marine life. The top commercial fishery landed in California is market squid, which is primarily caught within the boundaries of the CINMS [3,23,24,28]. A large majority of the squid is exported the European and Chinese markets. Indeed, fifteen percent of the total fishery landings caught in California come from a national marine sanctuary [9].

5. The destruction of southern California

During the last 150 years, the coastal watersheds and wetlands of the bioregion have been dramatically altered or destroyed by human activities. Fifty three percent of the drainage area of the SCB is controlled by major water retention structures, such as dams and reservoirs [30]. A total of 28 estuaries and wetlands occurred along the south coast in 1850 prior to development [10]. Most of the riparian areas of the coastal rivers and streams of the bioregion have been lost. Rivers have been rerouted and dammed. Creeks have been paved and channelized. Wetlands have been filled. Important fresh-water and salt-water inputs to coastal wetlands have been altered. Few estuaries are open to the necessary tidal influence. Notable examples of wetland types that largely have been eliminated in southern California include [4,24]: estuarine wetlands (i.e. salt marshes) as an entire subsystem at 75–90%; ‘the riparian community’ at 90–95% including loss of 40% of the riparian wetlands in San Diego County during the last decade alone; and vernal pools at 90%.

One sign of the decline in the general health of the coastal watersheds of the bioregion is indicated by the plight of the endangered southern steelhead trout. The number of southern steelhead has been reduced to about 200–300 in the region [18]. California ranks second in the US in the number of aquatic species that are threatened or endangered [31]. Every type of coastal ecosystem in southern California is considered threatened or endangered by the US Department of the Interior [25].

5.1. endangered marine bioregion

In a number of creative studies of the eastern North Pacific and the SCB, marine scientists have show a substantial decline in the abundance and distribution of animals, such as pelagic and shore birds, and habitats, including kelp and reef systems [3,19–21,24].

Evidence indicates that the maintenance of community structure and patterns of native species diversity have dramatically changed [22].

Recent data from extracted cores from the Santa Barbara Channel includes high quality information that can be tracked in increments of close to 50 years. The cores show rapid and extreme shifts in water temperatures during the last 60,000 years [5]. These shifts are known as 'regime shifts' that influence the distribution and abundance of marine animals and plants of the SCB [22]. Despite these major disruptions and regime shifts, no extinctions appear to have taken place among the benthic plant and animal communities [5].

A general summary of the decline in the general health of the SCB is depicted in Table 1:

Jackson et al. [12] show that overfishing is the primary cause of the decline in kelp ecosystem health. Since 1980 there has been a significant change in the level of resource use of the CINMS—new global markets emerged for market squid, urchins and live rockfish. Table 2 depicts the top five commercial fisheries landed from the CINMS.

The CINMS continues to be used as a resource rather than as a truly sacred place for marine life to flourish and reproduce. In 1994, for example, approximately 100 million pounds of market squid was landed in southern California [33]. Squid fishers travel far and wide—from Alaska to Los Angeles—to fish for market squid [28]. A majority of the market squid is caught within the nearshore waters of the CINMS. This nearshore marine area is the most biologically productive of the CINMS. Squid is a major part of the food chain of the CINMS, and is preyed upon by birds and mammals. In 1994, over 90% of the market squid was exported to China. Perhaps the greatest irony is that while major 'fishery resources' of the state are exported Californians import most of the fish they eat [20].

Table 1
Ecosystem disturbance of the SCB

The euphotic zone (upper sunlight zone of the sea, less than 120 m thick): there has been a long-term deficit in the supply of food necessary to meet the metabolic demands of the sediment community. Despite this decline in food supply, the food demand of the deep–benthic sea community remained constant.
Macrozooplankton: since the late 1970s, macrozooplankton volume in the California Current has declined over 70%, in concert with increasing sea surface temperatures. Reduced macrozooplankton has a major impact at higher trophic levels by changing the nature of the food supply.
Fishes and invertebrates: there has been a decrease in harvest for most categories of groundfish, rockfish, California sea urchin landings, landings of swordfish and selected shark species, California halibut, among others. Many of these declines began in late 1970s.
Oceanic birds: ecological theory predicts that in a stable ecosystem those species occupying high trophic levels maintain native species diversity and community structure. Upper trophic level animals such as pelagic birds are indicators of the health of the marine environment. Evidence suggests that the abundance of oceanic birds in the region and the SCB have declined steadily since 1988. Ocean warming and climatic events change pelagic bird abundance within the California current system.
Southern California Kelp: starting in the late 1970s, kelp forests have suffered great damage, and show a two-thirds reduction in standing biomass since 1957 in southern California kelp forests.
Global climate change: there is also some indication that the frequency of these climatic events may be increasing, and will have significant impacts on coastal and marine systems.

Source: McGinnis [18].

Table 2
Top five commercial fisheries landed from the CINMS *1988–1999*

	1988–1999			
Species/Species Group	Value	$	Percent	Rank (1999) Export (Y/N)
Urchin	53,706,734	41	2	Yes (Major)
Market Squid	49,105,451	37	1	Yes (Major)
Spiny Lobster	6,254,721	5	4	Yes
Rockfishes	5,085,262	4	5	Yes
Shrimp and Prawn	4,562,922	3	3	Yes

Source: [35].

Without a new institutional approach to the entire bioregion—one that involves the designation of large-scale no-take MPAs–the future of the more than human community of the coastal marine bioregion is rather dim [20,23].

6. The need for marine protected areas

To address the dramatic decline in the health of the oceans, a number of government and non-government entities support a serious overhaul of existing coastal and marine policies. For example, the independent Pew Oceans Commission [27] calls for 'immediate reform of existing U.S. ocean laws and policies' to protect and restore coastal marine ecosystems and associated biodiversity. The Pew Oceans Commission writes ([27] p. 3):

> "National ocean policy and governance must be realigned to reflect and apply principles of ecosystem health and integrity, sustainability, and precaution. We must redefine our relationship with the ocean to reflect an understanding of the land-sea connection and organize institutions and forums capable of managing on an ecosystem basis. These forums must be accessible, inclusive, and accountable. Decisions should be founded upon the best available science and flow from processes that are equitable, transparent, and collaborative."

Marine scientists recognize the importance of the establishment of large networks of marine protected areas or MPAs as key to the protection of coastal marine ecosystems [1,29]. A number of state and federal marine policy initiatives support the creation of a network of marine protected areas or MPAs [3,15,26,27]. Table 3 describes a range of federal and state initiatives that support marine life protection.

With respect to the northern Channel Islands, three advisory groups were established by the CINMS and the California Department of Fish and Game (CDFG) to consider the creation of marine protected areas- the Marine Reserve Work Group, Science Advisory Panel, and Socioeconomic Panel. This section focuses on the politics of the Marine Reserve Work Group or MRWG. The MRWG included 17 members that were purported to represent a wide diversity of interests and values within the 'community'. The MRWG included representatives from state and federal resource agencies, user groups (e.g. commercial and recreational fishers), local and national conservation organizations,

Table 3
Federal and state initiatives for marine protection

Title	Brief description of process or activity
California Interagency Marine Managed Areas Workgroup	California Resources Agency established this ad hoc advisory group in the summer of 1998 to evaluate an array of marine managed area classifications and make recommendations for improvements.
Assembly Bill (AB) 993. Marine Life Protection Act	Introduced in 1999, the Marine Life Protection Act went into effect in January 2000. The Act sets goals for a comprehensive marine protected area program in state waters (0–3 miles offshore).
Channel Islands Marine Reserves Working Group	From 1999 to 2001, the California Department of Fish and Game and the CINMS developed a joint federal-state process to consider the establishment of no-take marine reserves in the sanctuary.
AB 2800 (2000). Marine Managed Areas Improvement Act.	Effective January 2001, this Act identifies a mission and statement of objectives for state MMAs in California, and establishes a new classification system. This new classification system will consolidate over a dozen categories of MMAs into six, with clearly defined goals for each category.
President Clinton's Executive Order #13158 on Marine Protected Areas	Directs federal agencies to establish a national network of ocean conservation areas or marine protected areas (MPAs), and directs the EPA to take new steps to limit pollution of beaches, oceans and coasts.
Pacific Fisheries Management Council	The Council has begun the process of designating marine reserves as a fishery management tool for species under the Council's administrative jurisdiction.

and academics. The MRWG met for 22 months from July 1990 to May 2001. The group represented the first collaborative effort to develop and establish no-take MPAs in California.

In September 2000 the 15-member Science Advisory Panel recommended to the MRWG that a network of no-take marine reserves of 30–50% of the total national marine sanctuary would be required to protect a majority of species of the northern Channel Islands.[3] This Panel included many of the top marine scientists in the country, including Joan Roughgarden (Professor, Stanford University), Bob Warner (Professor and Researcher, National Center for Ecological Analysis and Synthesis), and Steve Gaines (Professor and Director, University of California Santa Barbara's Marine Science Institute). Marine scientists show the following [29]:

- Larger reserves (from 30 to 70% of habitat) can protect more habitat and populations of species while providing a buffer against losses from environmental fluctuation or other natural factors;
- No-take marine reserves can enhance species diversity, biomass, abundance and size of marine animals;
- Case studies of no-take marine reserves shows positive spillover effects from reserves into fishing areas;
- Reserves that are designed to protect ecosystem biodiversity can also protect fisheries.

The Panel recommendation included a range of maps and reserve scenarios that captured between 30 and 50% of the CINMS. The 'characteristic' scale associated with

[3] http://www.cinms.nos.noaa.gov/marineres/PDF/mpa_history%20of%20process.pdf

each recommendation, scenario and map determined the level of biodiversity and habitat protection. Panel members reached consensus on this recommendation; there were few objections by members of the Panel. Note the Panel's recommendation did not reflect the needs of all the species that are associated with the marine area. The Panel estimated that the 30% recommendation may protect up to 70% of the sanctuary's biodiversity while a 50% reserve design captures roughly 85%. The Panel did not believe that less than 50% would protect birds or mammals.

The Panel recommendation was based on the current state of the literature on the importance of marine protected areas as both a fishery management tool and biodiversity conservation strategy [1,29]. In addition, the Panel noted the importance of 'insurance' by developing larger reserves that can be resilient to major disturbance events and potential human impacts such as an oil spill and severe storm-related event. Any reserve scenario should include a multiplier (i.e. 120–180% of the reserve spatial design) in case of catastrophic events, such as an oil spill or a major warming event that can destroy nearshore habitats. This insurance factor was described as essential factor in reserve design given ocean-climate variability of the SCB.

The Panel provided the participants in the MRWG process with one of the prerequisites for marine ecosystem-based protection - no less than 30% of a network of no-take MPAs could protect a majority of the species of the CINMS.

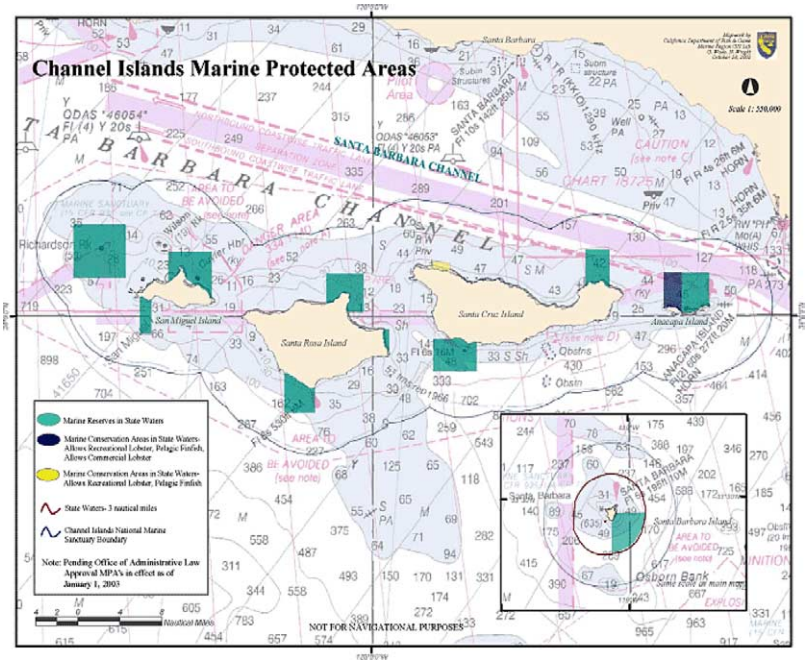
Unfortunately, the designation of the CINMS does not have a clear mandate to develop MPAs as a tool to protect coastal marine ecosystems. After several months of political debate the members of the MRWG failed to reach consensus on the value of the scientific information.[4] Ultimately, near the end of the negotiation process representatives from participating resource agencies (including the manager of the CINMS and regional manager of the CDFG), commercial and sports fishing interest groups, The Ocean Conservancy, compromised on the scientific information; all but one member of the MRWG supported the Science Panel's recommendation.

In May 2001, the MRWG was disbanded after failing to reach a consensus on the size and location of where to establish MPAs. After the break-up of the MRWG, the staff at the CDFG in conjunction with CINMS personnel proposed a network of MPAs in state waters (0–3 miles) of the northern Channel Islands. A range of alternative MPA designations was analyzed in terms of the economic costs to the fishing industries and various ecological criteria associated with marine life conservation and reserve design. In accordance to the priorities of the California Marine Life Protection Act [3], the focus of MPAs is to protect marine ecosystems. Both commercial and recreational fishing industries opposed the creation of a large network of reserves around the CINMS.

After a contentious environmental review process, in April 2003 new MPAs were formally adopted in California [3]. Map 4 depicts the final decision to create 12 distinct areas around Anacapa, Santa Cruz, Santa Rosa, San Miguel and Santa Barbara Islands.

Ten of the 12 MPAs are State Marine Reserves, where no take of living, geological or cultural resources is allowed [3]. Two of the MPAs, one on the northwest side of Anacapa and one at Painted Cave on Santa Cruz, are State Marine Conservation Areas where

[4] For additional information from a "resource use perspective" on the MRWG see Mark Helvey [36].



Map. 4. Channel Islands marine protected areas (in State Waters).

limited take is allowed.[5] The total area protected by the state within the CINMS is approximately 12% of the entire 'sanctuary', which represents the largest protected area within the eastern North Pacific, *or roughly 2.5% of the Bight*. By 2006, the federal government is expected to complete the environmental review process that could set aside an additional 12% of the CINMS waters.

Less than 30% of the CINMS *will likely* be protected in some form of a MPA. But the federal process for designating MPAs is a highly contentious one, and lacks the general leadership and support in the federal government.

The state began the planning process for MPAs off mainland California in 2005.

In general, the compromise on the best scientific information by the state (CDFG and CDFG Commission), federal resource agencies (National Marine Fisheries Service, National Marine Sanctuaries Program, National Park Service), and national environmental organizations, such as The Ocean Conservancy, during and after the MRWG process translates into a fundamental compromise on the intent of the management priorities set forth in the National Marine Sanctuaries Act. It also sets a poor precedent for the future of coastal marine ecosystem-based planning for the SCB.

A choice to protect large marine areas of habitat within the SCB challenges the institutional order to its very core. Some 16 federal agencies have a jurisdiction over the marine area. Historically, in many of these institutional arenas, commercial and

[5] www.dfg.ca.gov/mrd/channel_islands/index.html

recreational fishing industries dominate the marine policymaking processes [6,13,16,26]. As Okey ([26] p. 203) notes:

> "The dominant representation of special interests and self-interests on Regional Fishery Management Councils (i.e. the composition and organizational structure of decision-making bodies) is likely to be a fundamental cause of the failure of modern fisheries management and the subsequent degradation of common property resources in marine ecosystems."

State and federal agencies seem unwilling to move beyond a single-resource approach to protect marine ecosystems. Consequently species that do not have resource-value are rarely considered important to general economic production. Beyond the economic value of 'fisheries', fish are rarely described as important predators or indicator species and planned for accordingly. An ethic of stewardship and the move toward an ecosystem-based approach to marine planning and management is receding like a mirage in the Arizona desert.

While interdisciplinary marine science has come of age, marine life protection remains a secondary priority to marine resource use and economic development. It remains unclear whether the current federal administration will provide the necessary leadership or whether states will begin to support large-scale marine life protection efforts.

6.1. The pending regionalisation

In light of ecosystem decline, there has been an intense battle between competing interests who hold diverse values, institutional cultures, and worldviews about how to protect and use the marine life of the bioregion. This future direction of marine life planning and management is reflected in two recent commission reports—the PEW Oceans Commission Report [27] and the US Commission on Ocean Policy Report [32]. Both commission reports focus on emerging crisis - we have failed to protect marine life and marine ecosystems may be on the verge of collapse. Both reports focus on the need to develop new 'regional councils' that can better protect marine ecosystems. The US Commission on Ocean Policy ([32], p. 55) writes,

> "The *voluntary* establishment of regional ocean councils, developed through a process supported by the National Ocean Council, would facilitate the development of regional goals and priorities and improve responses to regional issues. Improved coordination of federal agencies at the regional level would complement the establishment of regional ocean councils, improving the federal response to state and local needs while furthering national goals and priorities. The development and dissemination of regionally significant research and information is imperative to meet the information needs of managers and support ecosystem-based decisions [my emphasis]."

The focus on the voluntary regional councils reflects the lack of commitment on the part of the US Commission to support formal policy innovation and regulatory rulemaking. Voluntary regional councils will not likely have formal regulatory authority;

these types of councils are often ad hoc, advisory decision making bodies. The US Commission states ([32], p.55),

> "The regional ocean councils are not intended to supplant any existing authorities, such as the Regional Fishery Management Councils, state agencies, and tribal governments. Rather, the councils will work with these authorities to further regional goals, providing a mechanism for coordination on myriad regional issues. However, the structure and function of a council may evolve over time. For example, participants might choose to pursue more formal mechanisms for implementing decisions, such as interstate compacts, interagency agreements, or changes to regulatory requirements."

Both commission reports recommend the use of MPAs as a tool in the development and implementation of large-scale ecosystem-based planning and management. But to protect marine ecosystems, the PEW Oceans Commission supports a major overhaul of existing Regional Fishery Management Councils. One reason for this is that these councils are 'captured' by interests that support fishing activities and the unsustainable use of marine life [26]. The report from the US Commission on Ocean Policy does not recommend major reform of fishery management institutions. This commission prefers the status quo.

'Regionalisation' of the primary institutions that are responsible for planning and managing human resource use and ecosystem-based protection of the Southern California Bight seems inevitable. Indeed, the US has a rich history of regionalisation [17]. If future regional councils are patterned after Fishery Management Councils, there will be little hope for true institutional learning and ecosystem-based planning. While we should recognize that we cannot 'manage' marine ecosystems, regional councils should focus on the development of various incentive and regulatory tools that can limit the human impacts to coastal marine systems.

6.2. The tragic choices ahead: ecological scale and the scope of conflict

We cannot abolish the paradox that is inevitable to a global economy through planning or institutional reflection. To protect large coastal marine bioregions, we face tragic choices between large-scale economic use and the preservation of enough habitat to enhance general ecosystem health and integrity. Large-scale marine bioregional planning and management is more than a matter of science: it also necessitates ethical, political, and economic choices. In some cases, these choices are more readily absorbed into human institutions.

Indeed, the debate and negotiation over the establishment of no-take marine reserves in the CINMS is a reflection of a conservation conundrum: The greater the scale and scope of conflict surrounding a conservation decision, the more potentially tragic the choice to protect the habitat will be. More often than not, economic interests in institutional arenas support economies based on ecological exploitation. This has certainly been the case in the tragic history of the over-exploitation of commercial fisheries [16].

A decision for large reserves threatens the prevailing form of order and the conventional approach to single-species resource management. Basic to the tragic form is its recognition of the inevitability of unresolved tensions that exist between diverse

interests. A tragic choice is defined as a policymaking situation that demands that a society choose between fundamental values. The question is whether human beings and their institutions are willing and able to make tragic choices to protect marine biodiversity.

Scientists document the tragic natural history of ecosystem decline and species extinction. Vague appeals to 'regionalization', democratic process, collaborative decision making or bioregionalism may be no guarantee that the fundamental conflicts between ecosystem-based sustainability and industrial order are resolved. There may be no relationship between substantive procedures, such as collaborative planning, and substantive outcomes, e.g. the system is healthy. To protect multiple species from biological collapse and extinction requires a tragic choice to conserve.

With respect to bioregional planning, conflict between participants who hold contending cultural beliefs and values is unavoidable [34]. Generally, as spatial, temporal, and other scales of policymaking expand, the scope of conflict expands to include more people in the decision-making situation. As the range of interests in decision expands, conflict between fundamental values becomes inevitable. A layered approach to ecosystem-based protection that employs milder and less restrictive measures at progressively larger spatial scales sounds like a reasonable political idea, but from a bioregional perspective, species that depend on large areas are put at risk. The choice for less restrictive government measures at larger spatial scales can lead to the tragedy of species extinction.

To summarize, coastal marine ecosystem protection requires a tragic choice between fundamental values: (1) The value of ecosystem-based protection requires large-scale, integrative approaches and bioregional strategies that can protect the ecological linkages, relationships and function of coastal marine ecosystems, and (2) The value of large-scale marine biodiversity conservation leads to an expanding scope of social conflict. Conflict between fundamental values (e.g. resource use versus biodiversity protection) is unavoidable and will have tragic consequences. Conflict cannot be avoided.

This tragic scenario involves a process of 'negotiating ecology', which includes the following [34]:

(1) Perceptual factors and values influence the interpretation of science;
(2) The way science enters the planning process is bound by value-based differences and the structure of the decision making process;
(3) There exists an interplay between claims of scientific and local knowledge;
(4) Science is 'situated' and contestable;
(5) There is the absence of unity and consensus in the planning process; and
(6) Scientific information does not resolve political conflict.

7. The future

This essay has identified important events in the natural history of the Southern California Bight. Virtually every coastal watershed of southern California has been

redirected. The defining watershed of the region, the Los Angeles River Basin, was destroyed for the sake of flood control and urban development.[6] As biophysical and chemical processes are changed by human activity, the general health and integrity of the coastal marine bioregion is degraded to the point where animals, such as shorebirds, plants, and fishes decline.

Moreover, there has been no large-scale protection of coastal or marine ecosystems of the region. In 1999, the California Marine Life Protection Act (Chapter 10.5, Section 2851 [g]) indicated that the proportion of genuine no-take marine reserves in California and federal waters (0–200 miles offshore) is *six thousandths of one percent*, or .06%. (14 square miles out of 220,000). There are a range MPAs offshore California, but few are no-take reserves [15]. In 2003 the level of marine area set aside as a no-take MPA by the State represents a *mere .4% of the SCB and 2.5% of State waters* [3].

As with many other marine bioregions of the world, there are a number of important threats to the future of this marine bioregion.

7.1. The threats of global economy and climate change

The expansion of a global economy has resulted in a substantial increase in international vessel traffic through the Santa Barbara Channel. The CINMS is located about 70 miles northwest of the Los Angeles/Long Beach Harbor. The Los Angeles-Long Beach Harbor is the busiest harbor in the US, with thousands of vessels using the facility annually. Containerized trade at the Port of Los Angeles has grown 150% since 1990, and the Santa Barbara Channel is a main thoroughfare to this Port [24]. There has yet been a contemporary profile of the risks of increased vessel traffic to marine life of the SCB.

The expansion of the global economy and the increase use of vessels of the marine bioregion pose a major threat to the health and integrity of coastal marine ecosystems. Shipping continues to have the potential to expand the rate of ballast-water introductions of non-native invasive species, which can have significant ecological and economic impacts. Invasive species have negatively impacted over 45% of listed threatened or endangered species in the US; the establishment of non-native species is second to habitat loss as the major threat to native species diversity [24].

Currently there is a paucity of data on the location and abundance of non-native species within the SCB. No comprehensive surveys have evaluated the scope and impact of non-native species on the bays, harbors and marinas of southern California. Studies of non-native organisms in the San Francisco Bay and Delta estuary have described no less than 234 non-natives, with over 100 different species of aquatic invertebrates alone. The general character and threat posed by the introduction of non-native species to the ecosystems of the SCB has not been systematically evaluated.

The impacts of global climate change cannot be controlled or managed by human beings. There are several interrelated impacts from climate change, including: the continued warming of the sea, significant sea level rise, loss of beach habitat and coastal

[6] See Mike Davis, [37].

erosion, destruction of private property within the coastal zone, significant loss of habitats and native species diversity, decline in food productivity and water shortage.

7.2. Needed institutional reform

This concluding section recommends the development of two large-scale management strategies. First, the development and implementation of coastal watershed-based programs for southern California should be a priority [19,20,34]. Second, an ecosystem-based approach to establish and designate a large network of MPAs should be adopted. General principles of regional governance are depicted in Table 4.

California remains one of the only coastal states in the US without a formal watershed-based program to protect biodiversity [31]. Watershed plans should incorporate the following general consideration and planning issues:

- Identification of sensitive habitat areas and important ecological linkages;
- Buffer and core zones to be protected near and adjacent to sensitive habitat areas;
- Identification of land-use activities in and near sensitive areas that are compatible with protection and restoration goals;
- Point and non-point source pollution sources and reduction programs;
- Strategies for ecological restoration of ecosystem functions which have been altered through human activity; and
- Alternative land-use practices that support general watershed health.

The designation of a large network of MPAs for the marine bioregion will require a kind of vision across boundaries. Table 5 provides an outline of values that should be part of coastal marine bioregional planning and management.

Table 4
Principles of Bioregional Governance

Type of ecosystem	Community with Ecology	Place-based Economy
	Restoring the Relationship between people and places	*Restoring the relationship between place and the mode of production and consumption*
Coastal	Watershed-based planning and management Promote place-based education and ecological literacy programs Protection of rural lands	Use of resources based on the values of intergenerational equity and environmental justice Development of regional markets for regionally-produced products Creation of value-added programs for sustainably produced resources
Marine	Establishment of large-scale no-take MPAs to protect marine ecosystems Protection of keystone species, such as birds and mammals Restoring the meaning of “sanctuary” Promote ecological literacy programs	Development of regional fishery trusts and cooperatives that promote regional markets for local fisheries landed

Table 5
The process of marine ecosystem management

Defining the problem
Emphasis is placed on healthy coastal marine ecological processes and linkages, and whole habitats and communities rather than individual species or projects.
Problems are defined without regard to jurisdictional boundaries or technical disciplines, and cooperative solutions and framework agreements are sought when the problem crosses jurisdictional boundaries.
Assessing marine ecosystem health
Assessment and monitoring strategies are prioritized in part based on their ability to provide insight into the strength and dependencies on one habitat or community upon another, and into both the structure and functional processes of the ecosystem.
Assessment and monitoring strategies are prioritized in part based on their ability to detect long-term trends and the cause of significant ecosystem change.
Assessment and monitoring strategies are identified that shed light on how the marine system sustains vibrant, healthy, and economically diverse human activities.
Ecosystem planning process
Ecological, social, and economic goals are integrated.
The Process involves diverse government and nongovernmental groups and advisory bodies that are representative of broad community interests.
Management strategies
Management works at multiple scales appropriate to the problem.
The precautionary principle is important to marine ecosystem planning and decision-making. The precautionary principle focuses on the goal of protecting all marine systems and species, regulates the over-use and human impacts to these systems, and links the land and sea. The precautionary principle is used to prevent harm to marine life rather than attempting to enhance or restore the system after ecological impacts and over-use.
Implementation
Management and research are implemented at multiple scales appropriate to the understanding of the problem, and to encourage experimentation and innovation. Adaptive management and public outreach or education is encouraged.
Emphasis is on cooperative, interjurisdictional, cross-boundary conservation partnerships, with potential new roles for government and nongovernment groups.
Project evaluation draws on socio-economic and ecological studies and expertise, as well as the local knowledge of biologists, citizens and resource managers.

Restoring a healthier human relationship to coastal and marine ecosystems is essential if we are to restore the ecology of the SCB. Indeed, how we organize will determine our shared fate. The animals and plants of a particular bioregion are part of a community. The word community derives from Latin *munus*, which has a number of meanings that are relevant here, including service, duty, gift and sacrifice. Community is an assemblage of individuals bound by a relationship and partnership. This relationship and partnership is based on mutual obligation, an exchange of gifts, and shared service. A system of shared service in a community connects a culture to the natural terrain. Membership in a community requires the establishment of an intimate relationship with the landscape and seascape, the animals and plants.

There is a close relationship, interaction and connection between human beings, the soils, waters, plants and animals, or collectively: the bioregion. In southern California, the bioregion naturally extends to the marine ecosystems of the SCB. The greater maritime

bioregion carries within itself not only the nourishing energies that are needed by each member of the community; it also contains within itself the special powers of regeneration.

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