Sladek Nowlis, J. 2004. California's Channel Islands and the U.S. West Coast. Pp. 237-267 in *Marine Reserves: A Guide to Science, Design, and Use* (J Sobel, C Dahlgren). Island Press, Washington, DC (USA).

Marine Reserves

A GUIDE TO SCIENCE, DESIGN, AND USE

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ISLAND PRESS
WASHINGTON
COVELO
LONDON

Library of Congress Cataloging-in-Publication data.
Sobel, Jack (Jack A.)
Marine reserves : a guide to science, design, and use / Jack Sobel
p. cm.
Includes bibliographical references and index.
1. Marine parks and reserves. I. Title.
QH91.75.A1S63 2004
333.95'616—dc22 2003021205

British Cataloguing-in-Publication data available.

Printed on recycled, acid-free paper

Design by Kathleen Szawiola

Manufactured in the United States of America
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California's Channel Islands and the U.S. West Coast

JOSHUA SLADEK NOWLIS

Marine reserves have been promoted as a means to address a wide variety of management challenges, from conservation of natural systems to enhancement of fisheries production. There is a substantial and growing body of evidence and experience to inform marine reserve efforts, some significant parts of which were gained along the West Coast of North America. These results demonstrate that reserves maintain and restore exploited species and consequently maintain more natural balances within their borders. Despite strong evidence of their value, marine reserves are extremely rare and small along the West Coast, with the exception of a recently designated and extensive network of marine reserves surrounding California's Channel Islands, which greatly expanded the region's total marine reserve area. Several ongoing processes also have the potential to dramatically increase the region's collection of marine reserves, but these processes face big political challenges.

Several different pieces of state and national legislation have created a mosaic of marine protected areas (MPAs)—ocean areas with site-specific protections—along the West Coast. Few of these areas provide the comprehensive protections required of a marine reserve. In California, for example, of 113 MPA designations, 20 prohibit all commercial and recreational fishing while only 4 prohibit all forms of extraction, including scientific take (McArdle 1997; McArdle et al. 2003). Half of California's marine reserves and seven-eighths of their area were added in 2003 through designation of a marine reserve network in the Channel Islands. This designation makes up a substantial proportion of all ocean areas conserved along the U.S. West Coast and represents one of the most comprehensive and scientifically driven marine reserve or reserve

networks in the world. As such, it offers a unique opportunity to gain experience with this new form of ocean management and to learn more about the design and function of marine reserves.

This chapter first reviews the history of MPAs along the West Coast, from California to Washington, with a focus on the areas that receive the greatest protection. Next, it discusses some of the key insight scientists have gained from reserves along the West Coast of North America. It then highlights the recently completed Channel Islands process that created one of the world's first extensive networks of marine reserves. This process has set a new standard for conservation while providing a great opportunity to learn more about how and how well marine reserves work. Finally, it discusses the future of marine reserves in the region and several ongoing processes that might build on the successful experience to date and create additional highly protected ocean areas.

WHAT HAS BEEN ESTABLISHED

MPAs have existed on the West Coast for nearly a century, dating back to 1913. California has designated the first and the most MPAs and has also led in the designation of marine reserves (Fig. 8.1a–c). In all three states, these areas make up fewer than 1.5 percent of state[1] ocean waters along the West Coast (see Table 8.1). As a fraction of the United States' West Coast Exclusive Economic Zone, these marine reserves are almost imperceptible at less than 0.04 percent, or less than 1/2,500 even after the creation of a substantial network of reserves in the Channel Islands.

California

The oldest MPA along the West Coast is the Cabrillo National Monument, created in 1913 near San Diego, California. The area has been expanded since its creation and allows only fishing for finfish by hook and line (McArdle 1997). Two marine life refuges were added in the first half of the twentieth century: San Diego Marine Life Refuge established in 1929 and Hopkins Marine Life Refuge established in 1931. Both refuges were primarily intended to protect intertidal areas. Thus they prohibited the collection of invertebrate animals and marine plants but allowed fishing for fish (Joseph Wible, Hopkins Marine Station Librarian, personal communication, 10/30/01). The Pacific Grove Marine Gardens Fish Refuge was also established in 1931 and limited fishing to hook

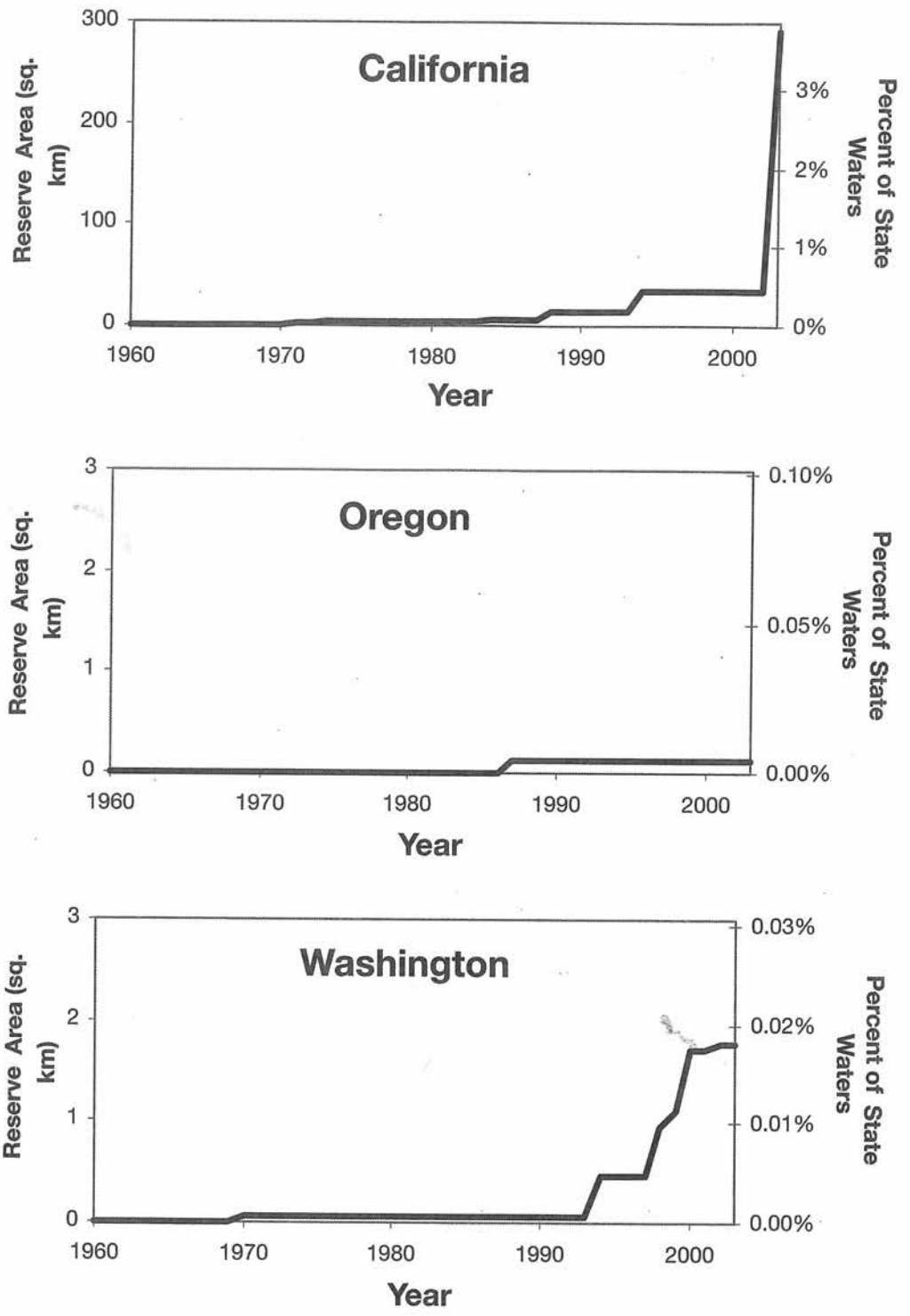


FIG. 8.1 West Coast Marine Reserve Area. Chronology indicates the build-up of marine reserves along the Pacific Coast. Note that state waters of this region consist of over 20,000 sq. kilometers. Also note that the Oregon and Washington's marine reserve areas are too small to be visible at the same scale as California's. Individual reserves are identified in Table 8.2.

Table 8.1 Proportion of State Waters and the United States Exclusive Economic Zone (EEZ) Encompassed by Marine Reserves

State	Marine Reserve (hectares = 0.01 km^2)	State Waters (km^2)	Exclusive Economic Zone (km^2), Including States Waters	Percent of State Waters in Reserves	Percent of State and Federal Waters in Reserves
California	29,230	7772	500,987	3.76	0.058
Oregon	12.9	2951	196,713	0.004	0.00007
Washington	177	9805	64,996	0.018	0.003
TOTAL	29,420	20,528	762,696	1.433	0.039

Reserves are defined as areas where all commercial and recreational fishing are prohibited, although some of the areas allow limited scientific sampling. See Table 8.2 for details on individual reserves.

State and federal waters area estimates were obtained from experts where possible (e.g., McArdle et al. 2003; Wayne Palsson, personal communication, 6/30/03). For Oregon, they were estimated using lengths of coastlines and width of jurisdiction (3 nautical miles for states, 200 nautical miles for EEZ) and should be treated as rough approximations.

and line (ibid.). The first close approximation to a marine reserve was established in 1965 with the designation of the Scripps Coastal Reserve at the site of the existing San Diego Marine Life Refuge. The Scripps Coastal Reserve prohibited fishing or collecting of any kind except by special permit (McArdle 1997).

From the 1970s until the mid-1990s, California was a national leader in establishing marine reserves. No-fishing zones were established at the San Diego–La Jolla Ecological Reserve (except a small western area open to limited types of fishing), created in 1971; all of Point Lobos and Heisler Park Ecological Reserves, both created in 1973; and the northeastern portion of the Anacapa Island Ecological Reserve, created in 1978 (McArdle 1997). Six other sites were designated in the 1980s and 1990s, which prohibit commercial and recreational fishing but allow scientific collection by permit (Table 8.2; McArdle 1997).

All other efforts to date were dwarfed by the marine reserves designated as part of an evaluation of the management of the Channel Islands National Marine Sanctuary. This process created twelve new MPAs, three of which expanded on existing MPAs. In total, they added nearly 260 km^2 of new marine reserve area where only scientific collection by permit is allowed (McArdle et al. 2003). Previously, there had only been about 35 km^2 of marine reserve in waters off of California and only 37 km^2 along the entire West Coast (see Fig. 8.1). With the addition of the Channel Islands network, reserves now encompass almost 4 percent of California state waters but still do not put an appreciable dent in the larger federal plus state area (see Table 8.1). Nevertheless, the magnitude and scientific underpinnings of the marine reserves in the Channel

Islands make them both a new standard for conservation and an unparalleled opportunity to examine how species and ecosystems change as a result of protection in a large network of marine reserves.

Oregon

Only a handful of MPAs exist in the state of Oregon. Most areas with potential to protect marine life in Oregon stop at the tide line and do not include subtidal habitats. Most are also open to some form of commercial or recreational fishing. Only the Whale Cove Intertidal Research Reserve includes subtidal habitats and prohibits the taking of marine fish, shellfish, and invertebrates (Didier 1998), but it does not prohibit collection of intertidal algae. The Whale Cove Reserve was created in the late 1960s and includes 12.9 hectares (0.129 km^2) of subtidal ocean habitat (see Table 8.2). Beyond this one small area, Oregon has nothing approximating a marine reserve at present (David Fox, Oregon Department of Fish and Wildlife, personal communication, 10/31/01), and the one area makes up 0.004 percent of state waters and an even less significant portion of state plus federal waters (see Fig. 8.1; Table 8.1).

Washington

Washington State created its first MPA in 1923, when the San Juan County/Cypress Island area was established. Within this area kelp may be collected as well as any type of seafood, but no other biological material can be taken without permission (Murray 1998). Even weaker regulations accompanied the creation of the Olympic National Park in 1938 and the San Juan National Historical Park in 1966, and these regulations remain weak today (Murray 1998).

It wasn't until the creation of the Edmonds Underwater Park in 1970 that Washington had something akin to a marine reserve. Edmonds prohibited the take of food fish or shellfish. However, it is situated around an artificial structure created by a dry dock sunk in 1935 (Palsson and Pacunski 1995). This park was expanded as part of the Brackett's Landing Shoreline Sanctuary Conservation Area in 1999. Marine reserves have also been designated in the past decade through several Conservation Areas: Octopus Hole and Sund Rock established in 1994; Orchard Rocks, City of Des Moines Park, and S 239th Street Park established in 1998; Saltars Point Beach and Waketickeh Creek established in 2000; and Keystone Harbor created in 2002 (Wayne Palsson, Washington

Table 8.2 Marine Reserves of the U.S. West Coast

Name	Location	Established	Size (hectares)	Notes
Scripps Coastal Reserve	CA	1965	35.2	
San Diego–La Jolla Ecological Reserve	CA	1971	145	Bait fishing for squid using a handheld scoop net is allowed in a narrow band on the western edge, otherwise no exceptions.
Point Lobos Ecological Reserve	CA	1973	278.9	No exceptions.
Heisler Park Ecological Reserve	CA	1973	12.8	No exceptions.
Anacapa Island Ecological Reserve Natural Area	CA	1978	12	No exceptions.
Hopkins Marine Life Refuge	CA	1984	32.5	
Catalina Marine Science Center Marine Life Refuge	CA	1988	844.9	
King Range (Punta Gorda) MRPA* Ecological Reserve	CA	1994	611. 5	
Vandenberg MRPA* Ecological Reserve	CA	1994	617	
Big Sycamore Canyon MRPA* Ecological Reserve	CA	1994	517.7	
Big Creek MRPA* Ecological Reserve	CA	1994	378.6	
Richardson Rock State Marine Reserve	CA	2003	6297	
Judith Rock State Marine Reserve	CA	2003	997	
Harris Point State Marine Reserve	CA	2003	3441	Small harbor exempted, estimated at 1/30 of the total area of 0.3559 ha.
Skunk Point State Marine Reserve	CA	2003	274	
Carrington Point State Marine Reserve	CA	2003	2601	
South Point State Marine Reserve	CA	2003	2112	
Gull Island State Marine Reserve	CA	2003	3149	
Scorpion State Marine Reserve	CA	2003	2014	
Santa Barbara State Marine Reserve	CA	2003	2581	
Anacapa Island State Marine Reserve	CA	2003	2288	Expanded on existing 12 ha Anacapa Island Ecological Reserve Natural Area. Total area expressed.
Whale Cove Intertidal Research Reserve	OR	Late 1960s	12.9	Also includes intertidal area where algae but no animals can be collected.
Edmonds Underwater Park	WA	1970	6.8	No exceptions.
Octopus Hole Conservation Area	WA	1994	11	No exceptions.
Sund Rock Conservation Area	WA	1994	28.8	No exceptions.
Orchard Rocks Conservation Area	WA	1998	41.9	No exceptions.
City of Des Moines Park Conservation Area	WA	1998	3.7	No exceptions.
S 239th Street Park Conservation Area	WA	1998	2.1	No exceptions.
Bracketts Landing Shoreline Sanctuary Conservation Area	WA	1999	17	No exceptions. Additional area added to Edmonds Underwater Park.

Table 8.2 (continued)

Name	Location	Established	Size (hectares)	Notes
Saltars Point Beach Conservation Area	WA	2000	1.6	No exceptions.
Waketickeh Creek Conservation Area	WA	2000	59.2	No exceptions.
Keystone Harbor	WA	2002	4.6	No exceptions.

These 32 areas are closed to all forms of fishing, with an exception only by permit for scientific purposes unless otherwise noted. The earliest site was designated in 1965, whereas the 10 most recent marine reserves were created in 2003.

* MRPA = Marine Resources Protection Act

Sources: McArdle (1997); Murray (1998); Didier (1998); McArdle et al. (2003); Gary Davis, Channel Islands National Park, personal communication, 10/30/01; Wayne Palsson, Washington Department of Fish and Wildlife, personal communication, 10/30/01; David Fox, Oregon Department of Fish and Wildlife, personal communication, 10/31/01.

Department of Fish and Wildlife, personal communication, 6/30/03). These new areas have made Washington State a national leader in establishing marine reserves, though they still encompass less than 0.02 percent of state waters.

Some additional areas are closed to all forms of fishing in Washington State but have not yet been adequately described or cataloged because of their nonconventional designations. The Zella P. Schultz/Protection Island area is leased by the United States Fish and Wildlife Service, which keeps all boats 200 yards away from shore and prohibits shore access from land. There are also other areas where a no-approach zone is maintained for security reasons. These areas include McNeill Island, the site of a federal penitentiary, and the Bangor and Bemerton Navy bases (ibid.).

HAVE THE RESERVES WORKED?

Despite the small size, paucity, nonscientific design, and uncertain enforcement of most marine reserves along the West Coast, we have learned a surprising amount from them and related studies. A limited number of studies have been conducted on marine reserves of the West Coast, but they have produced some important results. In addition to studies of actual reserves, there are some relevant studies of areas closed to particular types of fishing and studies examining the potential effects of large-scale closures. Although any closure can provide evidence for how individual populations or species may respond to a marine reserve, only actual marine reserves can provide insight into how ecosystems will respond to protection within a reserve while fishing takes place outside it (Tegner and Dayton 2000).

It is also relevant to look at the performance of conventional ocean management tools along the West Coast. The growth and spectacular crash of the

sardine fishery are widely known. This pattern of boom and bust has continued despite modern management techniques and institutions, including traditional California staple fisheries for abalone and rockfish and, more recently, sea urchins (Fig. 8.2a). This pattern has led to a reduction of total landings and an increasing reliance on the squid and kelp fisheries (Fig. 8.2b), which target important sources of food and shelter for other members of those ecosystems. Given the booming nature of the squid fishery (see Fig. 8.2a), there is reason to believe that it, too, may go bust.

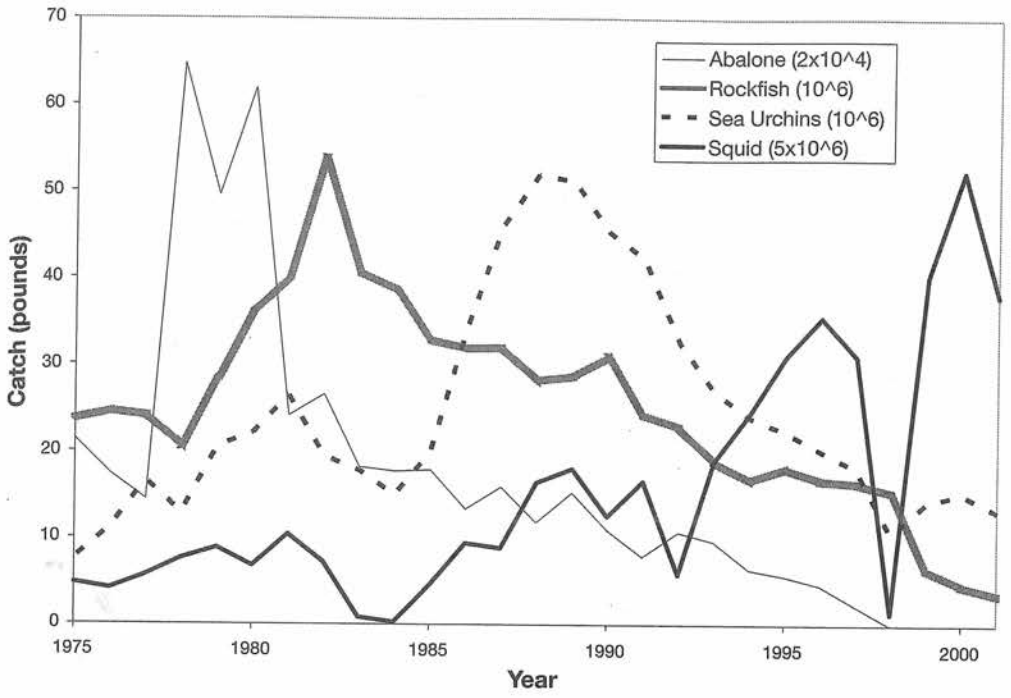
In total, the research conducted in this region provides strong evidence that marine reserves provide a variety of benefits, highlighting the promise of reserves as a valuable ocean conservation and management tool. Specific questions are addressed following here.

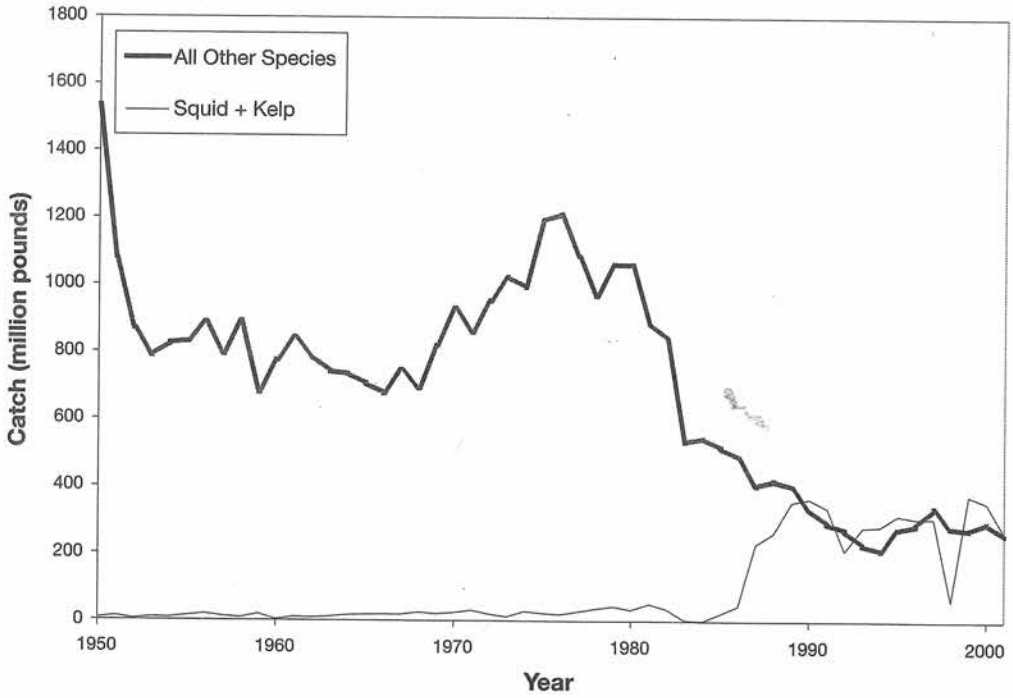
Do Reserves Increase the Size and Abundance of Target Species?

Increases in the size and abundance of target species are a crucial test of marine reserve function. If successful in this endeavor, and reserve design promotes some larval dispersal, reserves are likely to provide substantial fisheries benefits, particularly to overfished species (Sladek Nowlis and Roberts 1999). These benefits are especially promising for long-lived species because older, larger individuals typically produce far more offspring than their younger, smaller counterparts (Bohnsack 1996).

Rocky Reef–Associated Fish in Puget Sound, Washington. Palsson and Pacunski (1995) compared Edmonds Underwater Park—primarily used by recreational divers and part of the Bracketts Landing Shoreline Sanctuary Conservation Area, a marine reserve created in 1970—to four other nearby sites open to fishing. Three of these fishing sites had consistently fewer and smaller lingcod, copper rockfish, and quillback rockfish than Edmonds, but a fourth fishing area, Boeing Creek, had comparable numbers and sizes of quillback rockfish. However, there were more and larger copper rockfish and larger lingcod in Edmonds. The authors also observed more lingcod at Edmonds but this difference was not large enough to distinguish it from differences due to natural variability.

The authors also compared Shady Cove, an area closed in 1990 to all fishing except herring and commercial salmon, to a nearby area open to fishing. Their results here were less dramatic but still promising. Lingcod were 75 percent more abundant inside the closed area with two to three times the num-





FIGS. 8.2a and 8.2b. Status of California Stocks. Traditional staple fisheries in California, like rockfish and abalone, have collapsed. Overall landings are also down sharply, with an increasing reliance on the squid and kelp fisheries. From the National Marine Fisheries Commercial Landings Data (http://www.st.nmfs.gov/st1/commercial/).

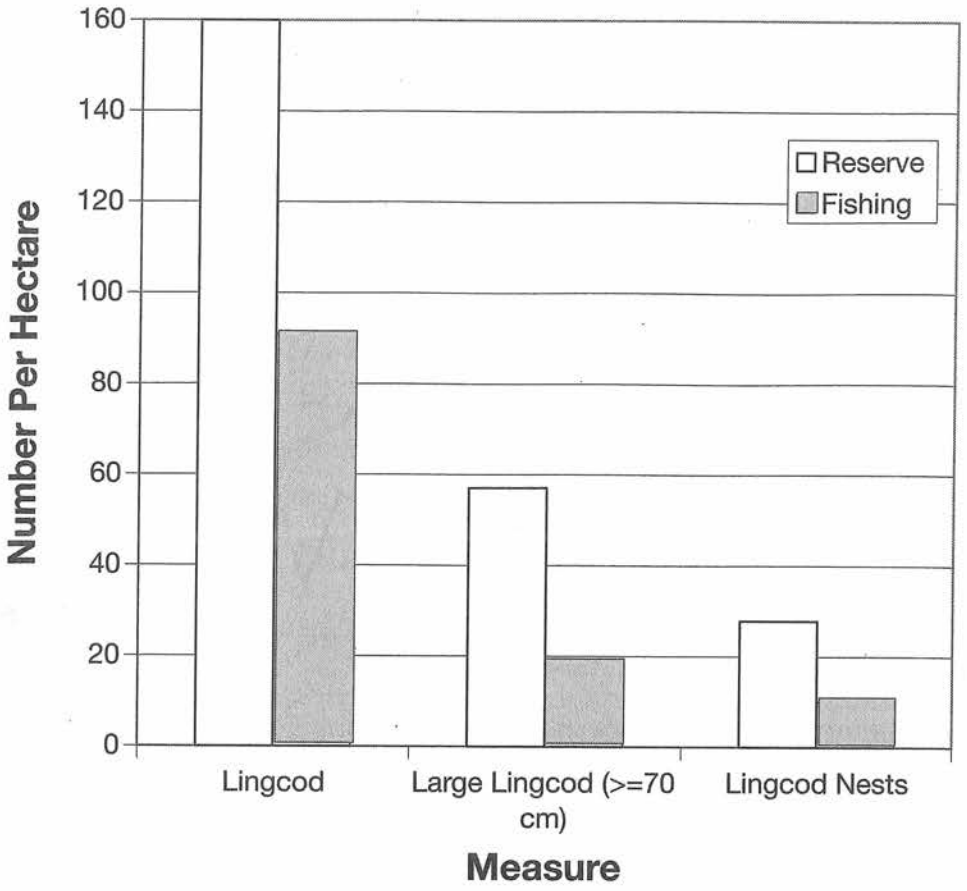


FIG. 8.3 Comparison of Three Measures of Lingcod Abundance inside and outside an Area Closed to Bottom Fishing. Lingcod were generally more abundant, and large lingcod and nesting lingcod (large males) were particularly abundant inside the closed area. Source: Adapted from Palsson and Pacunski 1995.

ber of large lingcod and nesting lingcod (Fig. 8.3). Copper rockfish were also more abundant in Shady Cove, but the overall weight of these species was similar in both areas. Quillback rockfish were too sparse for statistical comparisons. Overall, the studies of these two closed areas in Washington State suggest that they were effective at increasing the number and size of targeted fish within their borders despite the small size of these reserves.

Rocky Reef–Associated Fish at Three Central California Reserves. Paddack and Estes (2000) examined three areas closed to commercial and recreational fishing and compared them to adjacent fishing areas along California's central coast. Point Lobos Ecological Reserve was created in 1973 and bans all forms of fishing or collection. Hopkins Marine Life Refuge was created in 1931, though it did not prohibit all commercial and recreational fishing until it was expanded in 1984. The Big Creek Ecological Reserve was established in 1994.

Like Hopkins, it prohibits all commercial and recreational fishing but allows collection for scientific purposes. Point Lobos and Hopkins had larger fish than adjacent sites open to fishing, but a similar difference was not detected at Big Creek, the most recently designated site. And, while all three reserves showed indications of more abundant fish than adjacent fishing areas—54 percent more at Hopkins, 17 percent more at Point Lobos, and 25 percent more at Big Creek—these differences were not confirmed by the statistical method chosen by the authors. The differences are nevertheless worth considering because the statistical test lacked the power to confirm even fairly large differences between reserve and fishing areas.

Northern Abalone around Southern Vancouver Island, British Columbia. Wallace (1999) examined the abundance of northern abalone (*Haliotis kamtschatkana*) at eight sites in southern British Columbia, an area that is ecologically interconnected with Puget Sound, Washington. Due to a provincewide closure on the collection of northern abalone, abalone should have been recovering in most sites comparably, although the prison site had potential for greater abalone because it has been closed sine 1958.

Instead, the abundance of abalone was strongly correlated with the level of enforcement at each site. The military site, with the greatest enforcement, had more than twenty-four times as many abalone as the five undesignated and relatively poorly enforced sites (Fig. 8.4). The prison reserve and ecological reserve, with intermediate levels of enforcement, had fewer abalone than the military site but still fourteen to fifteen times as many abalone as the five undesignated sites. This study provides one of the best demonstrations that enforcement is crucial for the performance of marine reserves and other fishery closures. Moreover, it provides evidence that marine reserves are better and possibly more easily enforced than areas where some types of fishing are allowed.

Do Reserves Export Production to Fishing Areas?

Though many studies indicate a greater reproductive potential inside than outside reserves (e.g., Paddack and Estes 2000; Palsson and Pacunski 1995; Wallace 1999), few studies have been able to demonstrate the link between the buildup of fish in a reserve and increased production in nearby fishing areas. This demonstration can be tricky because of the biology of marine organisms and the small size of most existing reserves. It should be noted, though, that ocean managers routinely enact other regulations—such as quotas and size

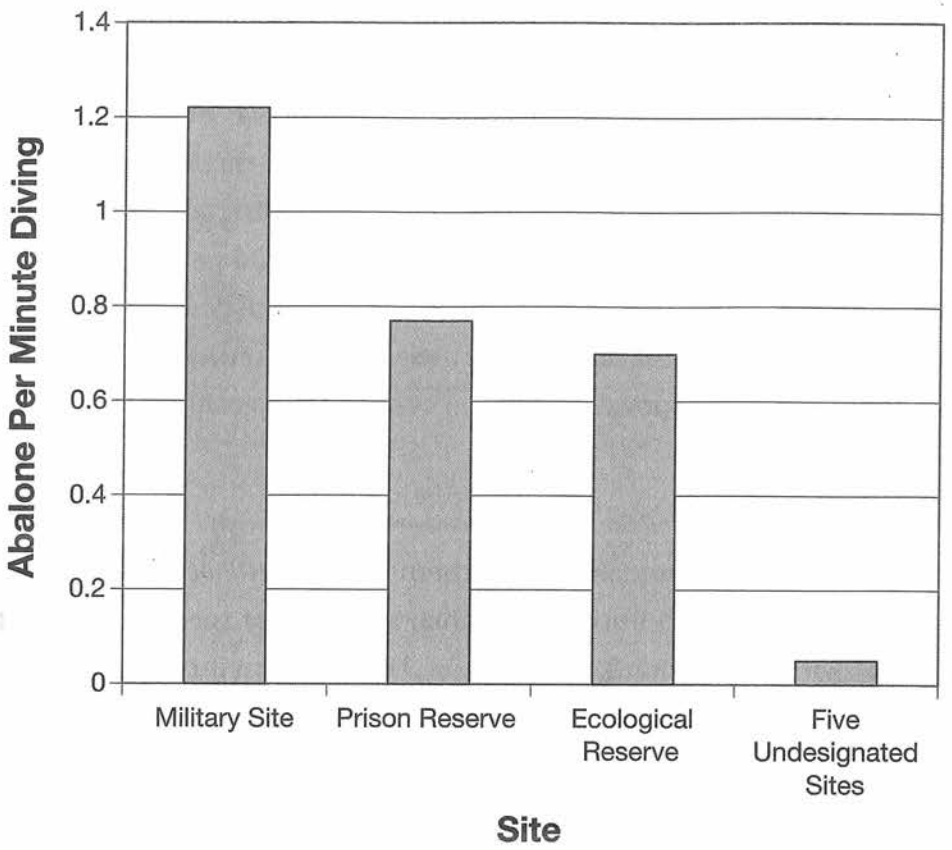


FIG. 8.4 Northern Abalone Abundance at Eight Sites in Southern British Columbia. Abalone were encountered with greatest frequency near a military base where enforcement of a provincewide abalone closure was best enforced. Abalone were moderately abundant at two no-fishing zones, one by a prison and another an ecological reserve, and virtually absent from five other sites where fishing for other species was permitted. Source: Adapted from Wallace 1999.

limits for fisheries—that also remain unproven in their ability to increase production of the fished population (see chapter 5).

Most marine organisms go through a waterborne larval stage during which they may drift or swim long distances. Because of the small size and high mobility of larvae, it is very difficult to actually study them in the ocean. Nevertheless, one of the best studies to examine the potential dispersal of larvae from a reserve was conducted along the West Coast.

Green Abalone, Southern California. Tegner (1992) studied the dispersal of green abalone (*Haliotis fulgens*) from a concentration of individuals created by transplanting adults to areas devoid of this species but within its historical range. This arrangement provided a reservelike situation where a concentration of adults might seed surrounding areas. The author found that after three

years, abalone had spread a few kilometers from the transplant sites and that most of the abalone were new recruits, presumably coming from the transplanted adults. Although recruitment patterns could not rule out the possibility that some larvae traveled to sites 45 to 100 kilometers away, the levels of recruitment at these distant locales was only 4 to 23 percent of the level of recruitment near the transplant sites. Abalone have a shorter larval life than most marine organisms (Prince et al. 1987). Consequently, there is a higher likelihood that abalone from a closed area will provide a measurable increase in recruitment to nearby areas but that this recruitment enhancement will tail off quickly farther away from the reserve.

Do Reserves Promote Ecosystem Function?

Anacapa Island Ecological Reserve, Channel Islands, California. The National Park Service, in cooperation with the State of California and the U.S. Department of Commerce, is responsible for monitoring the health of park ecosystems and has maintained a monitoring program of kelp forests around the Channel Islands for two decades. This monitoring protocol includes two sites within a marine reserve. The Natural Area of Anacapa Island Ecological Reserve lies along the north shore of East Anacapa Island, where all fishing was prohibited in 1978. The protocol also monitors fourteen fishable sites, including three near the reserve, allowing for comparison of fished and unfished ecosystems over a twenty-year period.

The results of this long-term monitoring study provide strong evidence that the ecosystem within the reserve has maintained a more natural ecological balance while fishing areas have shifted to an unnatural state. Fishing has reduced the abundance of several targeted populations, including California spiny lobster, which was 10 times more abundant inside the reserve, and a fish called the California sheephead, the large, colorful, and visible males of which were 1.5 times as abundant inside the reserve (Fig. 8.5a). Spiny lobsters and sheephead are key urchin predators in Southern California kelp bed ecosystems (Cowen 1983; Tegner and Levin 1983). Red sea urchins are also collected by people, but purple and white sea urchins are rarely fished and their populations have grown dramatically in fishing areas in the absence of predators or competitors. In fact, while nontargeted urchin densities have grown by only a factor of four in the reserve, they have increased by a factor of over fifteen in nearby fished survey sites since 1983 (Fig. 8.5b).

Giant kelp has suffered from heavy grazing by these nontargeted urchins in fishing areas, all but disappearing from fished survey sites near the reserve (Fig. 8.5c). Kelp is especially vulnerable to purple urchin outbreaks because these urchins cause disproportionate damage to holdfasts (Tegner et al. 1995), the part of kelp plants that anchors them to the bottom. In contrast, kelp has actually increased by more than 10 percent inside the reserve since 1983. Giant kelp provides food and shelter for many species in the kelp bed ecosystem (Dayton et al. 1998). Therefore, the protections afforded by the marine reserve have maintained a healthier and more natural kelp forest ecosystem than nearby fishing areas where kelp has virtually disappeared or at least been slow to recover from the most recent El Niño event. These findings bolster claims that overfishing has wrought havoc on kelp forest ecosystems over timescales of decades or more (Tegner and Dayton 2000) and highlight that even small reserves have the potential to protect ecosystems. These ecosystem benefits are more likely from a reserve than a less restrictive MPA where some types of fishing are allowed because fishing, even if restricted to only a few species, has the potential to disrupt natural balances and cause negative effects to ecosystems.

A study of warty sea cucumbers from the same area provided additional insight into the value of marine reserves as a control area with which to understand the effect of human activities. Schroeter et al. (2001) examined long-term monitoring data on the populations of this relative of starfish and sea urchins but more wormlike in appearance, which is the target of a new and growing fishery. These data showed declines of sea cucumbers in fishing areas, whereas populations stayed relatively stable within the Anacapa reserve. The scientists concluded that fishing was responsible for population declines of 33 to 83 percent. These results were especially dramatic considering that a more traditional assessment of this stock based on the ease of catching sea cucumbers had predicted that stocks were stable or increasing.

FIG. 8.5 Ecosystem Protection for a Small Channel Islands Reserve.
(A) The two dominant urchin predators—spiny lobster and male California sheephead—were more abundant inside the Natural Area of Anacapa Island Ecological Reserve, a marine reserve, than at three survey sites open to fishing nearby. Fishing heavily targets both of these species. (B) Consequently, urchin species that are not fished have increased markedly in fishing areas. (C) The nontargeted urchins have caused a dramatic reduction in giant kelp, the species that provides the foundation for the kelp forest ecosystem. Data from long-term kelp forest monitoring program of the Channel Island National Park.

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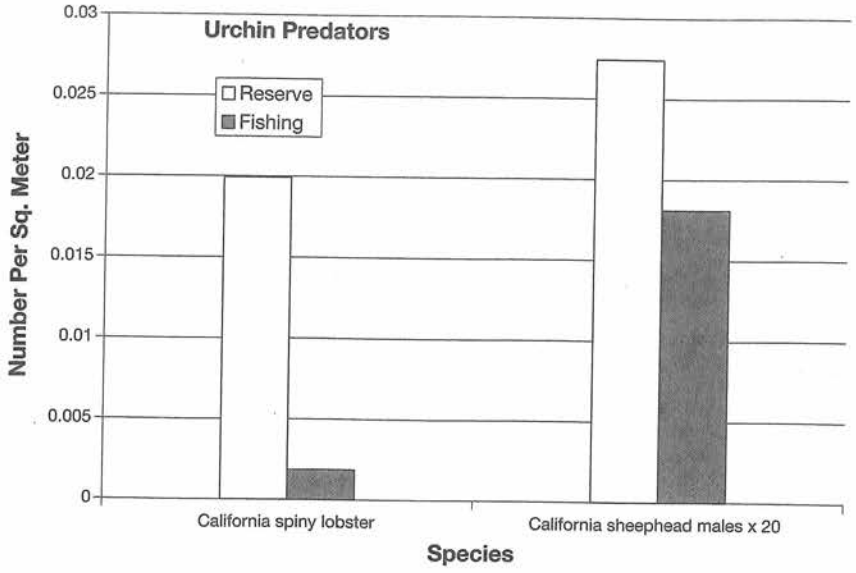

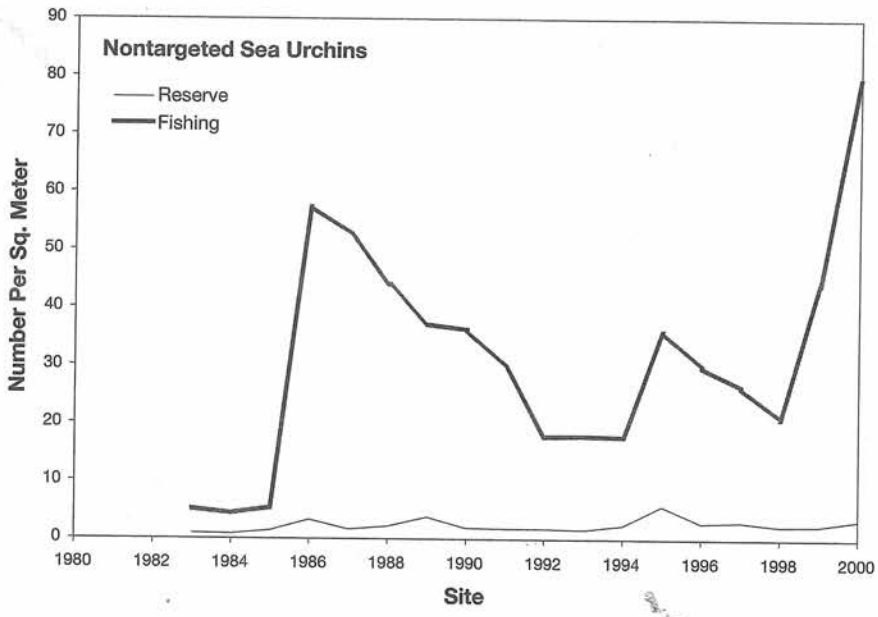

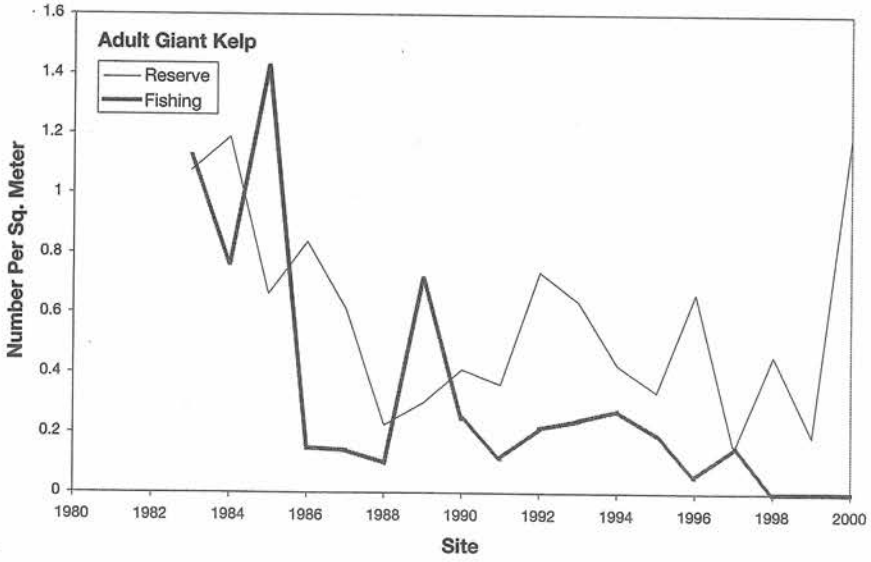

THE CHANNEL ISLANDS MARINE RESERVE NETWORK—A NEW FRONTIER

Although there are many ways marine reserves could be designated, not all fare equally at providing a scientific foundation, involving local communities in the designation, or garnering and wielding public support. California was home to a complex and involved process that considered and ultimately designated a network of marine reserves in the Channel Islands. This process, which provides several valuable lessons into the designation process, generally followed the one recommended in chapter 5, starting with the establishment of goals and objectives, followed by technical advice on how best to meet them, the development of proposals by the general public—including representatives of stakeholder groups—but supported by technical advice, and ultimately the choice of one alternative based on public support and scientific validity.

Background

The waters surrounding the Channel Islands out to 6 nautical miles were designated as a national marine sanctuary in 1980. The islands themselves plus ocean waters out to 1 nautical mile were declared a national park in 1986. These islands lie off the coast of Southern California, separated from the mainland by the Santa Barbara Channel. They are largely uninhabited and of a natural character, and the surrounding ocean environments are made diverse and productive by the intersection of cold- and warm-water ecosystems. The area boasts large populations of marine mammals, seabirds, and a rich array of coastal and oceanic environments. The channel has also been the target of substantial offshore oil development, and this development and a major oil spill provided much of the motivation for creating the sanctuary. The sanctuary's original regulations prohibited oil and other mineral extraction, pollutant discharges, and seabed alterations. Fifteen years later, a review of the sanctuary's management plan found fishing to be a threat that needed to be addressed.

In 1998, spurred by a concern about declines they had witnessed over decades, a group of sportfishing enthusiasts petitioned the California Fish and Game Commission to establish no-take marine reserves in the Channel Islands. Their proposal would have closed 20 percent of the waters out to 1 nautical mile from shore. Needless to say, this proposal caused a stir among the fishing and

conservation communities, but it also touched a nerve in the Commission, which had just been granted greater authority to manage California's oceans. The Commission did not accept the proposal but instead charged the California Fish and Game Department to develop a process in collaboration with the national marine sanctuary. The sanctuary staff was also motivated to take on such a task because they were beginning the first ever review of their management plan.

Process

Together, the sanctuary and the Fish and Game Department developed a science-informed stakeholder-driven process, whereby the responsibility of developing management alternatives was given to the Marine Reserves Working Group, a group representative of the various interests in the Channel Islands. The working group was supported by a scientific advisory panel, who provided general scientific criteria, developed analytical tools, and ultimately evaluated proposals on the degree to which they followed the scientific design criteria. In selecting scientists, the working group was solicited for nominations and also given a chance to veto scientists they felt were biased. Fishing interests utilized the veto power to oppose the selection of any scientist who had previously published on MPAs. They did so out of fear that some scientists had been co-opted on this issue by the conservation community, but this also eliminated from consideration the most knowledgeable scientists. The scientific panel was still of high quality, mainly because the rapidly growing interest in the subject among marine scientists meant that many of them were eager to work on this project and had already done background research and thinking about marine reserves. Had the scientific interest not been as dramatic, the broad veto of scientists who had published on the subject could have limited the value of scientific advice fed into this process.

One of the first steps taken by the working group was to adopt goals and objectives, or reasons why marine reserves should be considered in the Channel Islands. They developed five broad goals, two of which had the greatest influence on the process: ecosystem biodiversity—to protect representative and unique marine habitats, ecological processes, and populations of interest; and sustainable fisheries—to achieve sustainable fisheries by integrating marine reserves into fisheries management. These goals and objectives were forwarded to the scientific advisers, who were asked to provide relevant design criteria to achieve them.

Scientific Analyses and Recommendations

The scientists performed a broad literature review to develop general criteria, the most controversial of which was a recommendation that 30 to 50 percent of each habitat type in the sanctuary should be designated as marine reserves in a networked design (Airamé et al. 2003). Scientists on the advisory board had different rationales for this recommendation. Some believed that reserves needed to encompass this range of area to provide an adequate insurance factor given the uncertainty and poor health of many populations around the Channel Islands. Others took a simpler and more controversial view, eventually dubbed the "scorched earth" hypothesis. According to this line of thinking, 30 to 50 percent of each fishery population had to be protected to ensure that fisheries would be sustainable. These scientists did not believe other management techniques could guarantee this level of protection, and they concluded that reserves of this size would be an adequate and appropriate way to do so.

The scientists also focused on distributing the reserve areas so that they covered each of three regions within the Channel Islands—a cooler water region more characteristic of ecosystems to the north, a warmer water region more characteristic of ecosystems to the south, and an intermediate zone with some characteristics of each of the other two regions (Airamé et al. 2003). They also recommended that each habitat type within each region be well represented in the reserve network. They based habitat types on a variety of different measures and made habitats the focus because of their ability to serve as a surrogate for biodiversity (see chapter 5 for more details).

In addition, the scientific advisory panel developed a decision-making tool to guide stakeholders as they looked for favorable reserve siting alternatives (Fig. 8.6) that might also meet the scientific design criteria (Airamé et al. 2003). The decision tool was based on habitat and fishing effort data and was designed to give anyone feedback about the design of a marine reserve network. The tool was made available to members of the working group and the general public. Interested people could draw lines designating a potential marine reserve network, and the decision tool would provide feedback as to how well the network encompassed representative habitat types and on the amount of fishing it would displace. The concept was that the habitat inclusiveness gave an indication of the ecological value of a reserve proposal while the displaced effort gave an idea of how much short-term socioeconomic cost it would create. The designer could then make small modifications to improve their design or scrap the idea and try something else. The scientists also did their own analysis using

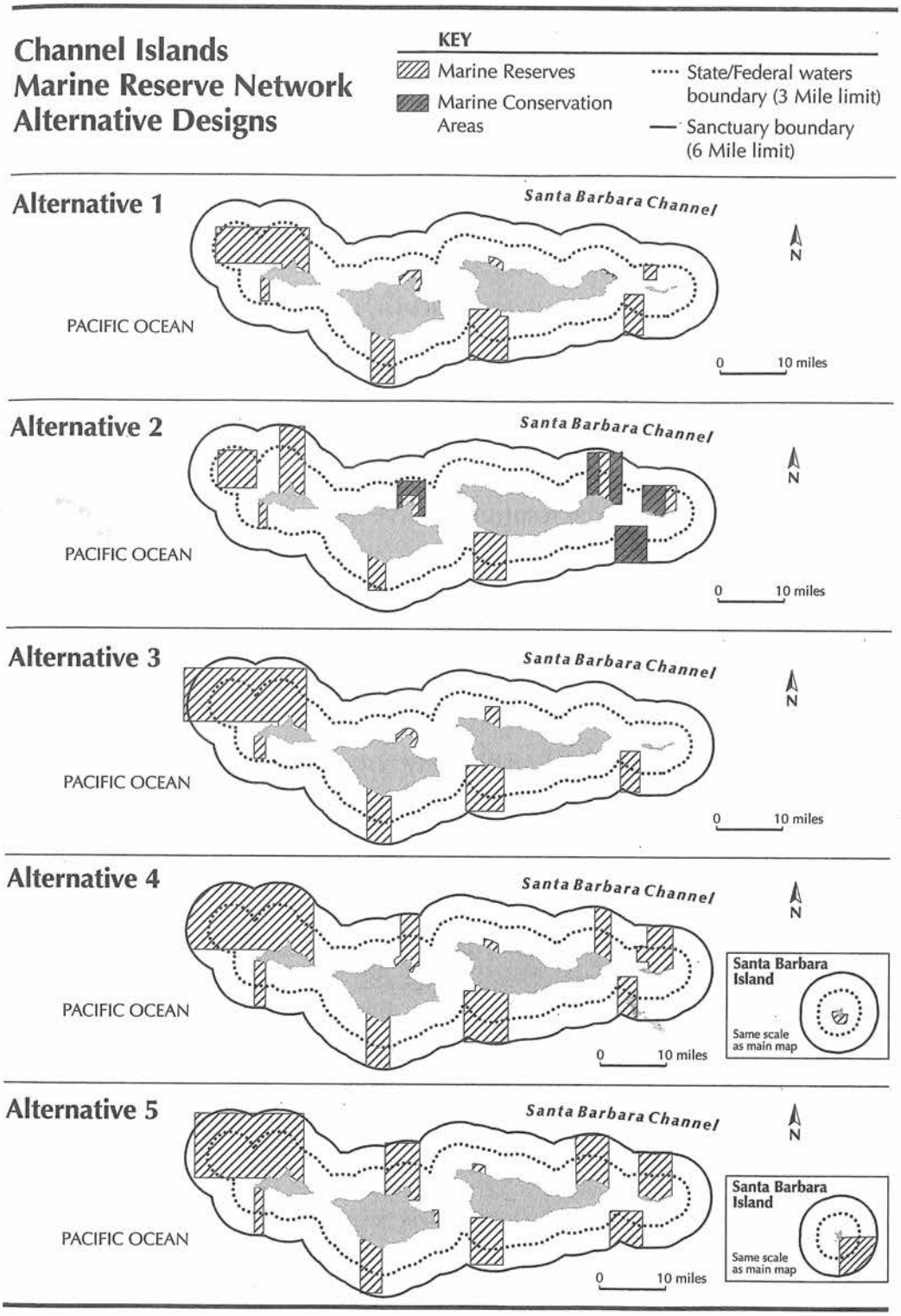

FIG. 8.6 Alternative Marine Reserve Network Design Configurations Proposed for the Channel Islands during the Designation Process. The SITES computer decision-making tools provided an ability to both create and evaluate alternative designs with respect to a variety of criteria.

the decision tool to highlight high and low priority areas for inclusion, characterizing these in terms of the efficiency of the design (Airamé et al. 2003). In other words, they showed some areas that, if included in the reserve network, would give more protective bang for the buck.

Through these efforts, the working group produced a number of marine reserve proposals, ranging from 8 to 50 percent of the sanctuary. However, they were unable to find consensus on any one proposal even after twenty-four meetings over a two-year period. In particular, the important commercial fishing areas tended to be toward the western (more seaward) part of the islands, whereas the important recreational fishing areas tended to be closer to the mainland. Each sector of the fishing fleet could develop a proposal with some scientific merit, but without much overlap. If one only looked at closing areas supported by consensus, the resulting reserve network was a third of the minimum size recommended by the scientists and did not represent all habitat types or even all of the islands. In May 2001, the Marine Reserves Working Group disbanded and passed on their range of proposals to the Fish and Game Commission, Fish and Game Department, and sanctuary staff.

With the dissolution of the working group, the Sanctuary Advisory Council took a more prominent role. This body also included representatives from a range of stakeholder interests in the Channel Islands National Marine Sanctuary. This council recommended that staff from the California Fish and Game Department and the Channel Islands National Marine Sanctuary develop a preferred alternative. They instructed staff to base this alternative on the efforts of the working group and to aim at balancing the various interests and concerns raised by that body. The preferred alternative encompassed approximately 25 percent of the sanctuary (Fig. 8.7), including good representation of various habitat types.

Outcome and Next Steps

This proposal was considered, along with several others, by the California Fish and Game Commission, who were targets of strong political campaigns by conservation and recreational fishing groups, both of whom turned out in large numbers at public meetings on the subject. Ultimately the Commission chose the preferred alternative in late 2002. Amidst strong political pressure from both sides, the Commission most likely made their decision mindful of the quality and integrity of the multiyear process that had carefully and systematically developed goals and objectives, sought scientific advice on how

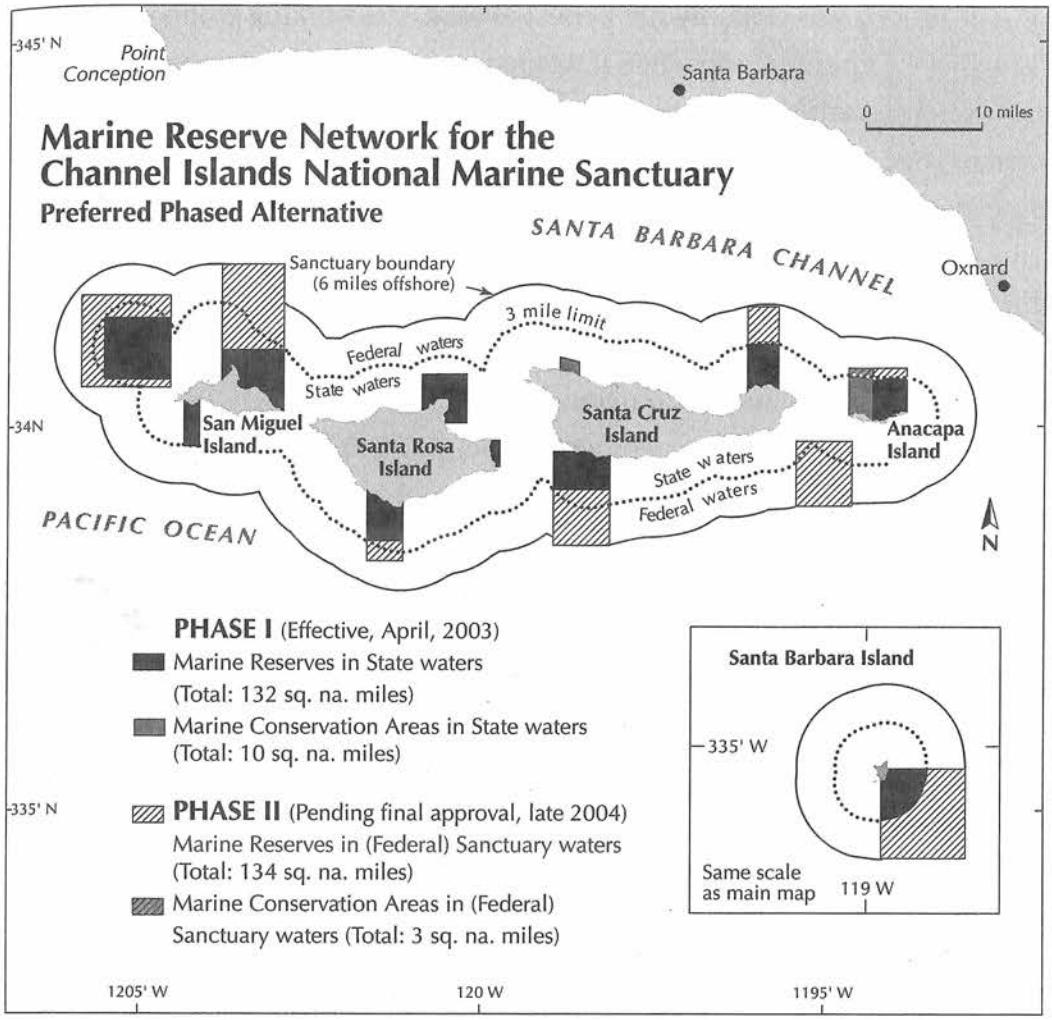

FIG. 8.7 The Preferred Alternative for the Channel Islands Marine Reserve Network As It Appeared in the California Environmental Impact Review (EIR) and As Approved by the State of California. This phase approach called for approving and implementing the portion of the network in state water first and then federal waters. The state portion is now final and the federal portion is currently pending approval.

to satisfy them, and strove to develop consensus proposals that met the scientific advice. This decision went into effect in 2003, creating ten no-take marine reserves and two additional MPAs where certain fishing activities were prohibited (see Table 8.2). However, the Commission's jurisdiction only extends 3 nautical miles offshore. Consequently, they were unable to establish marine reserves in the offshore federal waters of the sanctuary (which extend from 3 to 6 nautical miles). The National Oceanic and Atmospheric Administration supported the preferred alternative and thus is expected to designate the federal portions of these marine reserves in late 2004.

The process was certainly not perfect or easy. The working group was unable to achieve consensus, and when it wrapped up its work, it felt more like a melt down than a satisfying ending to two years of work. Of greater concern, some groups tried in earnest to circumvent the official process. Ultimately they were not successful, but such attempts (and the hopes they represented) detracted from efforts to gain consensus within the working group. Nonetheless, the broad elements of the process—goal setting, technical advice, stakeholder-driven proposal development, technical evaluation, and informed decision making—prevailed and the outcome could have been much worse. I personally learned that the broad steps were not enough to guarantee success. There also needs to be a commitment from all groups in the official process and consistent reminders that interested parties must play within that process or lose out on the opportunity.

The closure to fishing of a large network of marine areas, while supported by many scientists, has rarely taken place. The Channel Islands marine reserve network offers a great opportunity to learn about the responses of marine ecosystems to this level of protection. The network provides one of the first chances to study large tracts of highly protected ocean ecosystems as they recover from decades of human activities. It is likely that such studies will be conducted, despite the poor fiscal environment in California at present, because of the investment a number of scientists have already made and the engaging questions they can address through study of this system. If so, we can expect to gain a far greater understanding of how marine reserves operate not only individually but also as a network in sustaining ocean ecosystems, populations, and fisheries.

WHAT IS NEXT FOR THE WEST COAST?

A number of processes offer the potential to create additional MPAs and marine reserves along the West Coast. These include state and federal efforts to examine and coordinate MPAs and to manage fisheries.

California State Legislation

The California Legislature passed two key pieces of legislation with great potential to expand the use of MPAs and marine reserves in state waters: the Marine Life Management Act (MLMA) in 1998 and the Marine Life Protection Act (MLPA) in 1999. The MLMA transferred fisheries management authority from

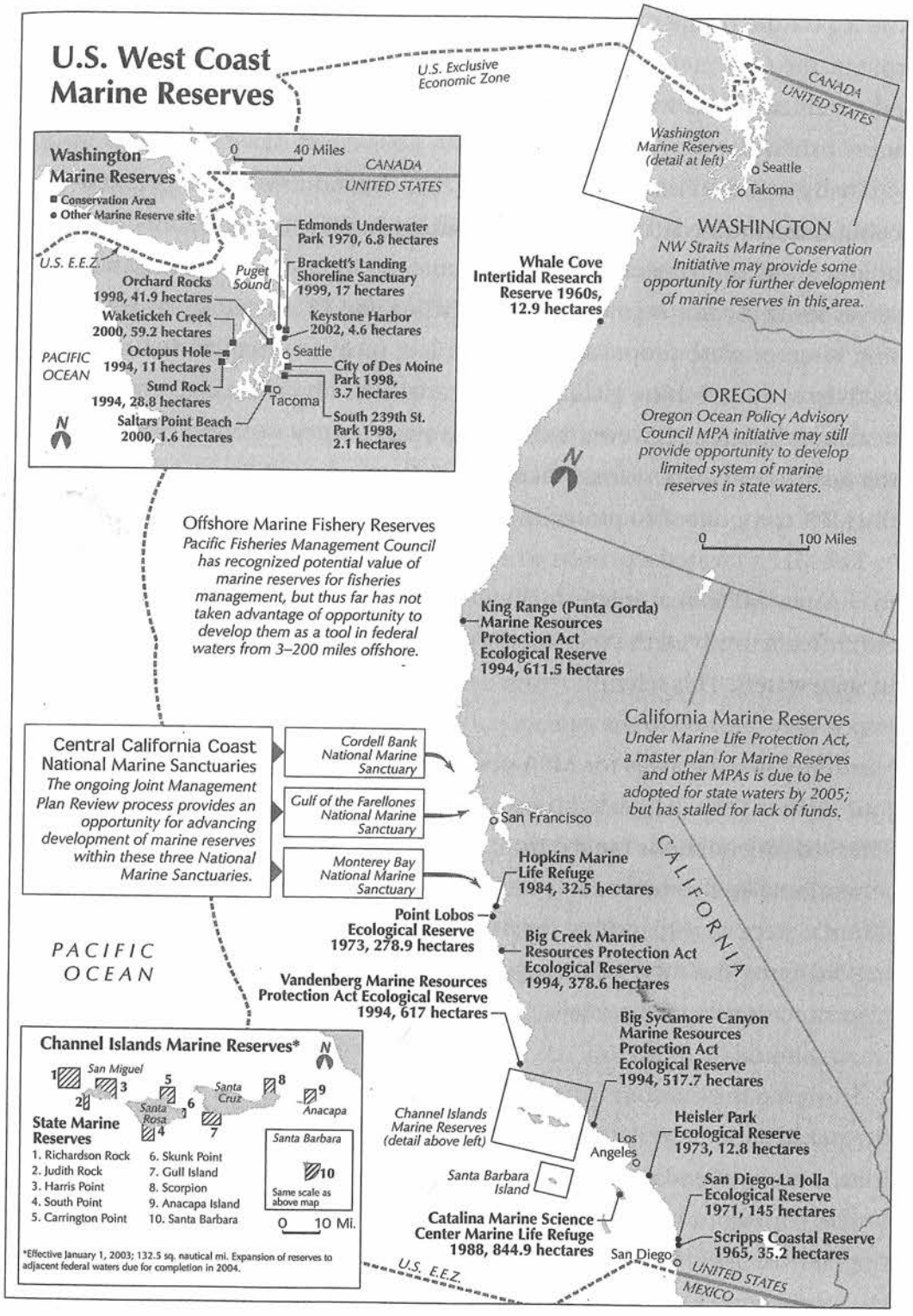

FIG. 8.8 Locations of All Current West Coast Marine Reserves and Opportunities for Future Marine Reserve Development.

the legislature to the California Fish and Game Commission, which played a role in the Channel Islands process. It also specified that three new fishery management plans were to be developed. One of these plans addresses nearshore fisheries.

The Nearshore Fishery Management Plan was adopted in 2002 and is now being implemented. The plan development process relied heavily on stakeholder input and generated draft recommendations for 10 percent marine reserves along the northern California coastline and 15 percent to the south. Marine reserves were proposed primarily as a means to reduce the chance of inadvertent overfishing given large uncertainties about the biology of several nearshore species. However, in the final version they were removed. Instead, the nearshore fishery management plan relies on the MLPA process to provide the MPA component to protect nearshore fish.

The MLPA created a process to examine and revise existing MPAs as well as to site new MPAs that might include marine reserves. It also established a scientific team to advise the state on the development of the master plan for MPAs in state waters. This scientific team developed a draft set of recommendations, which they released to the general public in July 2001. Their recommendations identified specific areas for MPA designations and varied in scope across the four regions they delineated (north, north central, south central, and south). The recommendations ranged from 4.5 to 8.9 percent of each region closed to recreational and commercial fishing, but with scientific sampling allowed. Additional areas were identified for closure to bottom fishing or commercial fishing, bringing the total MPA recommendations up to between 14.6 and 24.1 percent. On average, the scientific team recommended that 6.9 percent of state waters should be in marine reserves and 17.7 percent in some form of MPA.

However, these recommendations came without any prior consultation with the public, and both fishing groups and the conservation community called for the recommendations to be delayed until there could be a formal stakeholder consultation. As a result, the state extended the original deadline for the MLPA master plan. The draft is now due to be presented to the California Fish and Game Commission by January 1, 2005, and the Commission is to adopt a final version by December 1, 2005. These recommendations are to be informed by seven formal regional stakeholder panels with representation from a wide range of public interests, including sport and commercial fishing groups, conservation organizations, and representatives from education, tourism, and other interested parties. However, lack of funding has stalled this process and it is unclear how it will proceed during a state budget crisis.

State of Oregon's Ocean Policy Advisory Council (OPAC)

In July 2000, the governor of Oregon requested that the Ocean Policy Advisory Council (OPAC) review and make recommendations on MPAs in Oregon in consultation with stakeholders. That August, OPAC recommended that the state begin a public process to create marine reserves in state waters. OPAC's recommendations focused on the establishment of a limited system of marine reserves to evaluate their effectiveness, and it identified neither individual sites nor conservation or fisheries goals. The report recommended the use of a locally oriented public process, utilizing a reserve planning committee of stakeholders. In opposition to these steps, some factions have pressed a piece of legislation that would have effectively gutted the entire state ocean program. It is not clear at present whether the bill will pass, although even if it does amendments have taken out some of the most extreme provisions (Robert Bailey, personal communication, 6/20/03). This has not officially ended the process of adopting a series of small experimental marine reserves in Oregon, but the future remains uncertain.

Northwest Straits Marine Conservation Initiative

In 1998, Congress established the Northwest Straits Marine Conservation Initiative in Washington State. The initiative is a locally based, grassroots approach to improving the health of the marine ecosystem in the Northwest Straits, an area at the mouth of Puget Sound. In addition to addressing issues ranging from water pollution to derelict fishing gear, it is mandated to create a scientifically based system of MPAs. The initiative established seven marine resources committees (MRCs)—one for each county in the region—to discuss and recommend MPAs and marine reserves to a regionwide Northwest Straits Commission. The recommendations are to be implemented using existing local, state, and federal authorities. Several voluntary MPAs have been established by the MRCs and these groups continue to be a key source of advice to the State's Department of Fish and Wildlife as they consider establishing MPAs.

Federal Fisheries Management

The Pacific Fishery Management Council drafts recommendations to the secretary of commerce regarding federal fisheries management along the West

Coast. After a troubled history of declining fish populations, the Council established a two-phase process to consider marine reserves. In the first phase, the Council and its advisory bodies considered whether marine reserves would be a useful tool and, if so, for what specific purposes. The first phase ran from the spring of 1999 through September 2000. It culminated in February 2001 with the release of a report (Parrish et al. 2001) that asserted marine reserves had potential value as a management tool to address some of the challenges in the region. The Council chose to pursue marine reserves as a means to rebuild overfished fisheries. However, the Council has stalled on taking up the second phase, in which reserves would actually be implemented for this purpose, and has to date not established a single permanent marine reserve. Nevertheless, the Council has closed some large areas to some forms of fishing as a rebuilding measure for several species of rockfish.

Central California National Marine Sanctuaries

Central California is home to three national marine sanctuaries—Cordell Bank, Gulf of the Farallones, and Monterey Bay—which extend for hundreds of miles from Bodega Bay, north of San Francisco nearly to Morro Bay, near San Luis Obispo. These sanctuaries are undergoing a review of their management plan, one of the factors that spurred the creation of the Channel Islands marine reserve network. The review process does not require the creation of marine reserves but is intended to ascertain whether existing management measures are adequately protecting the marine environments within the sanctuary. Given the troubled state of many fish species in California (see Fig. 8.2a), it would not be out of the question for marine reserves to be expanded or wholly redesigned as part of the management plan review. At present, sanctuary staff are participating in other regional processes to consider and possibly enact marine reserves and other MPAs, and have established a working group, which has identified goals and objectives and various other background information. However, they are going to recognize the authority of the State of California in inshore waters, where marine reserves are most likely to be desired and effective.

DISCUSSION

The West Coast experience has taught us a great deal about the design, function, and designation of marine reserves. Though still a small fraction of the

state and federal waters in this region, marine reserves are becoming more common, larger, and better designed. Studies of these reserves have shown that they increase the size and abundance of many target species, have strong potential to export production to fishing areas, and promote the natural and healthy functioning of marine ecosystems. The West Coast experience has also taught us how to better conduct reserve designation processes.

The West Coast experience with marine reserves and MPAs parallels experiences from other parts of the world (see chapters 4 and 11). As is true in the West Coast studies, the creation of marine reserves has had dramatic effects on biological communities inside them worldwide despite the small size of most individual reserves and limited extent of reserve networks. Although individual studies are not always capable of demonstrating statistical proof of such changes because of a lack of replication or experimental controls (Rowley 1994), comparisons across multiple studies consistently lead to the conclusion that marine reserves contain more and larger fish within their borders than surrounding areas open to fishing (e.g., Halpern 2003).

The West Coast evidence on dispersal from reserves also parallels evidence from elsewhere. Reserves will not necessarily benefit fisheries for organisms with extremely limited dispersal unless the reserve units are small and numerous. With abalone in Southern California, for example, reserves would only provide fisheries benefits if the reserves were small enough to provide for dispersal to fishing areas only a few kilometers away. On the other hand, organisms that disperse too broadly may prove challenging to protect with reserves (Polacheck 1990). Fortunately, despite the long larval lives of most marine organisms and the resulting potential for broad dispersal (Shanks et al. 2003), studies have shown that a combination of oceanography and larval behavior can lead to significant amounts of local retention of larvae (e.g., Cowen et al. 2000; Swearer et al. 1999). Collectively, the body of work on larval dispersal suggests that many coastal marine populations retain a large proportion of larvae locally while some larvae disperse long distances.

The ecosystem shifts seen outside of the marine reserve off of East Anacapa Island, California, have parallel results from a number of other countries, including Australia, New Zealand, Kenya, Spain, and elsewhere, as discussed in chapters 4 and 11. Such shifts are fairly widespread in well-studied environments, but in many cases external factors such as runoff from land and sewage effluent can also play an important and sometimes synergistic role (Pinnegar et al. 2000). These processes introduce extra nutrients, fertilizing the ocean. Nutrients can play an important role because the ecosystem shifts are often

seen in the algal community, which for better or worse is more likely to thrive in the presence of extra nutrients.

In other parts of the world, fisheries benefits have often paled in comparison to nonconsumptive benefits from marine reserves. In Kenya, for example, nearly two-thirds of the fishing fleet quit fishing, most for jobs in the tourism industry, after the creation of a marine reserve network encompassing 65 percent of local fishing grounds (McClanahan and Kaunda-Arara 1996). The fishing community on St. Lucia also showed strong interest in tourism jobs during the designation of the Soufriere Marine Park. Though dive tourism is less significant along the West Coast, especially in the state of Oregon, there is a substantial dive industry in places like Puget Sound, Monterey Bay, Catalina Island, and San Diego, which is likely to benefit from the creation of marine reserves.

The designation of the Channel Islands marine reserve network opens a new frontier for marine protection with the potential to greatly improve the health of the region. The science-based, stakeholder-driven process succeeded in establishing the West Coast's first marine reserve network and changing the scale of marine reserve protection. Much can be learned from this experience. It shows that neither initial opposition nor controversy inherently means a death knell for a marine reserve proposal. Managers and supporters of the reserve network neither ran away from nor eliminated controversy, but they did overcome it. Strong science and an open public process were instrumental to this. Defining goals and objectives for the marine reserve network early in the process and developing scientific criteria to meet them were also key to this success. The scientific advisory panel and the decision-making tools provided credibility, flexibility, and support at key times. Although the Marine Reserves Working Group process did not achieve absolute consensus, it did provide a foundation for a set of alternatives that represented a range of views, allowed for a vigorous and public debate over these alternatives, and ultimately led to the development of a preferred alternative with enough public support to succeed.

In sum, there is strong evidence from the West Coast and elsewhere that marine reserves are effective at protecting populations from overfishing, exporting enhanced production to nearby fishing areas, maintaining healthy and balanced ecosystems, and providing nonconsumptive recreational and economic opportunities. Despite this evidence, marine reserves are still rare. The greatest potential for improving both fisheries and conservation on the West Coast lies in the creation of effective networks of marine reserves. There

is now evidence that such marine reserves can be successfully established on the West Coast when supported by strong science and sound public process. Whether additional networks will be created remains to be seen and hinges on uncertain processes under way in state and federal governments. Even the Channel Islands network is not yet complete, with the federal portion still needing to be finalized. The successful establishment of the region's first marine reserve network raises the bar for marine conservation and provides an opportunity for raising it further. Many people will be watching to see the impact of this reserve network. A strong research and monitoring program will likely be critical to evaluating this impact. Such a program is important to evaluate the success of the Channel Islands network for its own sake, but the extent to which it can demonstrate positive impact from the reserve network may also go a long way toward determining the success of other reserve efforts.

ACKNOWLEDGMENTS

I am especially grateful to Gary Davis, David Kushner, and the Channel Islands National Park for the foresight to collect a fantastic dataset on kelp forest ecosystems in the Channel Islands and for permission to have access to this data. I am also indebted to Wayne Palsson, Bob Bailey, Dave Fox, Joe Wible, Alan Baldridge, Warner Chabot, Greg Helms, Doug Obegi, and Karen Reyna for providing valuable information on the history of MPAs and ongoing processes. Finally, I wish to thank Rebecca Sladek Nowlis for her valuable comments on a draft of this manuscript.

ENDNOTES

1. State waters extend 3 nautical miles along the West Coast, with federal jurisdiction beginning at the end of state waters and ending 200 nautical miles out, at the end of the United States' Exclusive Economic Zone.

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