
Science and Society: Marine Reserve Design for the California Channel Islands

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Abstract: *We explored the interaction of science and society in attempts to restore impaired marine ecosystems in Channel Islands National Park and National Marine Sanctuary, California. Deteriorating resource conditions triggered a community's desire to change public policy. Channel Islands National Park, one of 40 marine protected areas in the U.S. National Park System, was proclaimed a national monument in 1938 and expanded substantially in 1980 by an act of Congress. Collapse of marine life populations and loss of 80% of the giant kelp (*Macrocystis pyrifera*) forests in the park between 1980 and 1998 showed that habitat and water quality protection alone had not secured sustainable ocean ecosystems or fisheries. The failed fishery management strategies and practices prompted formal community and agency requests in 1998 for a network of reserves protected from direct fishing impacts to serve as marine recovery areas. A 2-year attempt to build a community consensus based on science for a reserve network successfully identified recovery goals for fisheries, biodiversity, education, economics, and heritage values. Nevertheless, the community group failed to garner unanimous support for a specific reserve network to achieve those common goals. The group submitted a recommendation, supported by 14 of 16 members, to state and federal authorities in 2001 for action in their respective jurisdictions. California adopted the half of the network in state waters in 2003. This process exposed the socioeconomic factors involved in the design of marine protected areas that can be negotiated successfully among groups of people and factors determined by nature that cannot be negotiated. Understanding the differences among the factors was crucial in reaching consensus and changing public policy.*

Key Words: adaptive management, kelp forest, national park, ocean conservation, public policy

Ciencia y Sociedad: Diseño de Reservas Marinas para las Islas Channel de California

Resumen: *Exploramos la interacción de ciencia y sociedad en intentos para restaurar ecosistemas marinos deteriorados en el Parque Nacional Channel Islands y en el Santuario Marino Nacional, California. El deterioro de las condiciones de los recursos motivó el deseo de una comunidad para cambiar las políticas públicas. El Parque Nacional Channel Islands, una de las 40 áreas marinas protegidas en el Sistema Nacional de Parques de E. U. A., fue proclamado monumento nacional en 1938 y fue sustancialmente expandido en 1980 por un decreto del Congreso. El colapso de poblaciones de vida marina y la pérdida de 80% de bosques de *Macrocystis pyrifera* en el parque entre 1980 y 1998 mostró que la protección del hábitat y de la calidad del agua por sí solos no habían proporcionado ecosistemas marinos ni pesquerías sustentables. Las estrategias y prácticas fallidas de gestión de pesquerías impulsaron, en 1998, que la comunidad y agencias solicitaran una red de reservas protegidas de los impactos directos de la pesca para funcionar como áreas de recuperación marina. El intento, durante dos años, de construir un consenso comunitario con base científica para una red de reservas exitosamente identificó metas de recuperación de pesquerías, biodiversidad, educación, economía y valores patrimoniales. Sin embargo, el grupo comunitario falló en acumular soporte unánime para una red de reservas específicas para alcanzar esas metas comunes. En 2001 el grupo sometió una recomendación, apoyada por 14 de 16 miembros, a las autoridades estatales y federales para acciones en sus respectivas jurisdicciones. California adoptó la mitad de la red en aguas estatales en 2003. Este proceso expuso los factores socioeconómicos involucrados en el diseño de áreas marinas protegidas que pueden ser negociados*

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con éxito entre grupos de personas y factores determinados por la naturaleza que no pueden ser negociados. El entendimiento de estas diferencias entre los factores fue crucial para alcanzar el consenso y cambiar la política pública.

Palabras Clave: conservación de océanos, bosque de algas, manejo adaptativo, políticas públicas, parque nacional

Introduction

The eight California Channel Islands, 260–25,000 ha each, lie 20 to 110 km off the coast in the southern California bight. Four islands in the north mark the southern boundary of the Santa Barbara Channel (34°N), whereas the remaining four are scattered from Los Angeles to San Diego. Beginning early in the twentieth century, many people recognized the four northern islands (San Miguel, Santa Rosa, Santa Cruz, and Anacapa) and one of the southern islands (Santa Barbara) as special places for inspiration, recreation, and environmental benchmarks, designating them and portions of the surrounding ocean in an overlapping mix of jurisdictions, as protected areas, including an international biosphere reserve, a national park, a national marine sanctuary, two state areas of special biological significance, three state ecological reserves, a state natural reserve, and a private reserve (McArdle 1997). These designations identified a societal intent to make this place one of the most protected areas in the public domain.

In 1938 President Roosevelt proclaimed Anacapa and Santa Barbara islands as Channel Islands National Monument. This action initiated the current era of special attention afforded these islands and adjacent waters. Thirty years later the U.S. National Park Service, expressing concern about declining sea life in the monument, restricted fishing and kelp cutting to half of the monument's waters, which extended 1.9 km around each of the islands. This action created two fully protected reserves, one on the east side of Santa Barbara Island (~1000 ha) and one on the north side of Anacapa Island (~2200 ha), that were in place for 10 years. The State of California successfully challenged the authority of the federal government to regulate take of living marine resources in the monument in 1978 (U. S. Supreme Court, 436 US 32). That decision extinguished the federal reserves. California replaced them the same year with "state ecological reserves," which allowed fishing and kelp cutting, except in a 13-ha natural area along 2.5 km of the north shore of East Anacapa Island to a depth of 18 m. In 1980 the U.S. Congress expanded the monument to include the remaining three northern islands and established Channel Islands National Park, which included 50,600 ha of the surrounding submerged lands and waters. Later that year President Carter declared the waters within 11 km of the five park islands to be a national marine sanctuary.

The National Park Service, collaborating with the California Department of Fish & Game and Channel Islands National Marine Sanctuary, began monitoring ocean resources in Channel Islands National Park in 1981 to augment traditional fishery landings data collected since 1916 in California (Davis 1989; Davis et al. 1994; Leet et al. 2001). Fishery-independent measurements of fish, invertebrate, and algal demographics (density, distribution, and size structure) for 87 taxa in the East Anacapa Natural Area and in the adjacent and distant fished areas of the park and sanctuary revealed dramatic differences over 20 years (Davis et al. 1997; Davis 2005).

In fished areas, abalone (*Haliotis rufescens*, *H. corrugata*, and *H. sorenseni*) densities declined from 2,000/ha to < 12/ha (the lower limit of detectability), and juvenile recruitment virtually ceased, whereas in the reserve densities remained low but stable, at > 200/ha (Davis et al. 1992; Davis 1995). The withering syndrome (Friedman et al. 1995) that afflicted intertidal black abalone (*H. cracherodii*) equally in the reserve and out of it during the late 1980s and early 1990s (Lafferty & Kuris 1993; Richards & Davis 1993) played no demonstrable role in these subtidal abalone population declines. California closed all abalone fisheries in southern California in 1997 to protect remnant brood stocks (Karpov et al. 2000). *H. sorenseni* was declared an endangered species by the federal government in 2001 (Hobday et al. 2001). Exploited large (>105 mm test diameter) red sea urchins (*Strongylocentrotus franciscanus*) similarly declined in fished areas from densities of 12,000/ha in the early 1980s to < 2,000/ha by the 1990s, whereas they remained high (12,000–15,000/ha) in the East Anacapa Reserve. Other fishery-targeted species such as warty sea cucumbers (*Parastichopus parvimensis*), spiny lobsters (*Panulirus interruptus*), and several fishes (e.g., California sheephead [*Semicossyphus pulcher*] and rockfish [*Sebastes* spp.]) showed similar patterns of extreme depletion in fished areas but remained stable at high levels in the reserve (Lafferty & Kushner 2000; Larson & Julian 1999; Schroeter et al. 2001; PISCO 2002).

Unexploited species showed very different population dynamics during this same period. Within the reserve densities of small purple sea urchins (*S. purpuratus*) remained low (1,000–5,000/ha), whereas in fished areas their densities fluctuated widely from 50,000/ha to 400,000/ha, controlled by lack of food and disease rather than predation by spiny lobsters and California sheephead

and competition with other sea urchins and abalone as they were in the reserve (Lafferty & Kushner 2000). Densities of the state-protected marine fish the garibaldi (*Hypsipops rubicunda*) remained the same in both reserve and fished areas throughout the two-decade period. The high densities of purple sea urchins overgrazed the giant kelp, reducing nearly 80% of the kelp forest in the park to "urchin barrens" for most of the period.

Kelp forests in the small reserve at East Anacapa Island retained their resilience throughout the study period. They recovered quickly (within a year) from major disturbances associated with El Niño/Southern Oscillation events in 1982-1983, 1987-1988, 1992-1993, and 1997-1998. Outside the reserve these events reduced kelp canopy and produced pulses of drift kelp, followed by increased spatial dominance of purple sea urchins, brittle sea stars (*Ophiotrix* sp.), and small sea cucumbers (*Cucumaria* sp.) in areas formally dominated by giant kelp. These different responses to disturbance appeared to be related to changes in community structure and subsequent changes in biological interactions (competition and predation) because other physical and chemical environmental factors related to air and water (e.g., sea temperatures and pollution) were virtually the same inside and outside the reserve (SCCWRP 2004).

Social Processes for Change in Public Policy

Public agencies, several local communities, and environmental organizations responded to these undesirable changes in ocean resource conditions by searching for new approaches to stewardship. In 1998 a group of recreational anglers (Channel Islands Marine Resources Restoration Committee) and Channel Islands National Park requested that the California Fish and Game Commission establish a network of marine reserves (no-take zones) in the park that constituted no less than 20% of the park's waters to restore the integrity of park ecosystems and to begin rebuilding depleted populations. In 1999 the California legislature passed the Marine Life Protection Act (Chapter 10.5 of the California Fish and Game Code, Sections 2850 to 2863) to improve the array of Marine Protected Areas (MPAs) in California waters to protect habitat and ecosystems, conserve biological diversity, provide a sanctuary for fish and other sea life, enhance recreational and educational opportunities, provide a reference point against which scientists could measure changes elsewhere in the marine environment, and help rebuild depleted fisheries. The California Department of Fish and Game was charged with implementing the provisions of the Marine Life Protection Act.

Channel Islands National Marine Sanctuary established a community-based advisory council in 1998. It was to provide advice on protecting resources, identifying crit-

ical issues, research objectives, and educational opportunities, and to assist in developing an informed constituency to increase awareness and understanding of the purpose and value of the sanctuary. The Sanctuary Advisory Council comprised 10 government seats and 10 nongovernment seats, representing commercial fishing, conservation, recreation, education, business, tourism, research, and three citizens at large. The sanctuary manager proposed to the California Fish and Game Commission that the advisory council be used to respond to the request for marine reserves at the Channel Islands and to establish a process for considering specific reserves. The commission accepted and charged the Department of Fish and Game with cochairing a Marine Ecological Reserve Working Group of stakeholders with the sanctuary manager.

The Sanctuary Advisory Council created the working group around a core of five council members, a Sea Grant Extension marine advisor, and a representative of the California Fish and Game Department. Ten additional members were selected to represent a range of community perspectives (e.g., sport fishing, commercial fishing, and kelp harvesting). All 17 members of the working group played the same role. Fourteen of the 17 members represented fishing interests, as participants, managers, researchers, or advocates. Two professional meeting facilitators were engaged, one from a local community and one from a federal agency. The working group formally adopted ground rules for consensus that required members to offer positive alternatives if they disagreed with a group proposal or to withdraw from the process. The working group selected a 16-member Marine Reserves Science Panel to provide scientific guidance. Members of this panel were selected by the working group to represent broad local knowledge, diverse disciplines, and institutions. The group considered only scientists with no published "agenda" on marine reserves. A postdoctoral fellow supported by the sanctuary provided technical support for the science panel. The sanctuary also provided a five-person socioeconomic study team to help the working group evaluate various social and economic implications of marine reserves.

The working group met formally 25 times in 22 months, with numerous informal meetings and work sessions and four large public meetings. The total cost of this effort was difficult to estimate, but exceeded US\$1 million. After nearly 2 years of discussion, education, and negotiation, the working group failed to reach consensus on a recommendation for a network of marine reserves through structured decision making and sophisticated decision support tools (Kleindorfer et al. 1993). At the end, the facilitators allowed sportfishing business representatives to block consideration of any reserves in the Californian biogeographic zone of the islands (Fig. 1) without offering the group an alternative that met the collective goals or withdrawing from the process, contravening

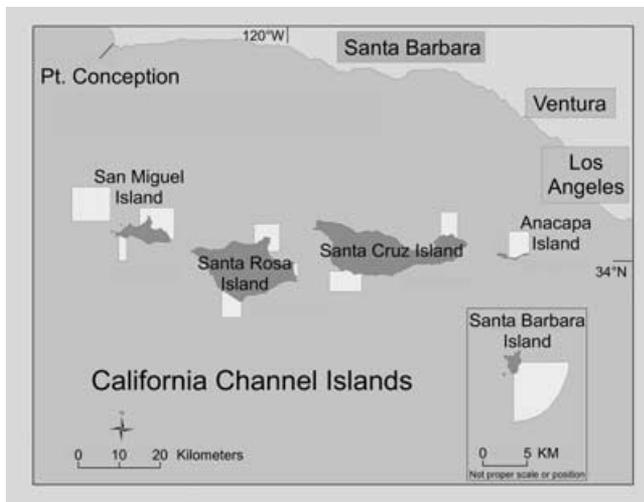


Figure 1. Network of no-take marine reserves (shown as unshaded polygons) at the California Channel Islands, established in April 2003.

the group's formally adopted ground rules for consensus. When the working group rendered its recommendations, the Sanctuary Advisory Council reviewed the process, found it fair and open, and forwarded the recommendations to the sanctuary manager. The working group had recommended that the cochairs resolve the differences expressed by the working group to reach a compromise position. They did, and forwarded their recommendations to the commission. The commission held four additional public meetings on the recommended reserves around the state during the next year and then voted 2 to 1 to create a network of 10 marine reserves (no-take areas) that constituted approximately 19% of the state waters around the park islands, effective April 2003.

Outcomes

Two of the most important outcomes of the marine reserve design process were a consensus statement of the problem to be resolved and a set of shared community goals for restoring ecosystem integrity and depleted resources that could be achieved with marine reserves (Channel Islands National Marine Sanctuary 2002). The agreed-on problem statement indicated that increased human populations in southern California had stressed coastal resources from fishing, pollution, and other uses; that advanced technologies had increased the capacity of fleets to catch fish; and that variable environmental factors such as El Niño altered resource availability. The group agreed that marine organisms were now scarce relative to the past and that the group shared an interest in understanding changes in resource abundance, reversing declining trends, and restoring ecosystem integrity

and resilience. They also agreed that it was necessary to develop new ecosystem-based management strategies such as no-take reserves to protect, maintain, restore, and enhance living marine resources. The group further recognized that reserves provided a precautionary measure against effects of expanding human influences and management uncertainties, offered educational and research opportunities, and provided environmental benchmarks.

The working group also developed and reached consensus on five goals and associated objectives for marine reserves at the California Channel Islands: (1) ecosystem and biodiversity: protect representative and unique marine habitats, ecological processes, and populations of interest; (2) socioeconomic: maintain long-term socioeconomic viability while minimizing short-term socioeconomic losses to all users and dependent parties; (3) sustainable fisheries: achieve sustainable fisheries by integrating marine reserves into fisheries management; (4) natural and cultural heritage: maintain areas for visitor, spiritual, and recreational opportunities that include cultural and ecological features and their associated values; and (5) educational: foster stewardship of the marine environment by providing educational opportunities to increase awareness and encourage responsible use of resources.

The science panel provided an ecological framework and design criteria for networks of marine reserves. The framework included considerations of biogeographic representation, individual reserve size, human threats and natural catastrophes, habitat representation, vulnerable habitats and species, monitoring sites, and connectivity. Because the study area encompassed three biogeographic regions, a representative network would include multiple sites within each region. Individual reserves needed to be large enough to sustain viable populations of resident predators. To achieve biodiversity and fisheries goals, the science panel recommended including a minimum of 30–50% of the planning area in reserves. To ensure adequate habitat diversity in reserves, the planning area was classified by substrate, depth, exposure, and dominant plant assemblages. Particularly vulnerable habitats (e.g., kelp forest, eelgrass [*Zostera* sp.], and surf grass [*Phyllospadix* sp.]), seabird rookeries, and pinniped haulout sites were identified as unique features to receive special attention. Extant monitoring programs could provide opportunities to compare changes inside and outside reserves before and after reserve designation and to determine whether reserves had sufficient fixed monitoring sites inside and outside the network.

Hundreds of people participated directly in this process at public meetings and work sessions and by reviewing documents. The primary public agencies received more than 9100 written comments from the public in the first 2 years alone, and 94% were in favor of a network of reserves that met the science panel's recommendations. Despite this apparent public support, two representatives

of sportfishing industries ultimately opposed the final recommendation for a reserve network by the remaining 14 members of the working group.

The final marine reserve network established in 2003 (Fig. 1) met most of the science panel's design criteria for size, number, and distribution of reserves. The 10 reserves ranged from 477 ha to 10,974 ha (8 were > 3,500 ha, most likely a minimum viable size for this ecosystem based on habitat requirements of minimum viable populations of resident predators; Davis 2004) and totaled 45,088 ha. They were well distributed biogeographically, with three or four reserves in each of the three regions. With regard to habitats, depths ranged from shore to 550 m and included hard and soft substrates, with adequate examples of kelp forests, sea grass beds, submarine canyons, and adjacent wildlife rookeries. The network fell short of the science panel's recommended minimums of 71,192–118,652 ha needed to meet the biodiversity and fisheries goals, but provided an opportunity to evaluate the design criteria and efficacy of reserves to improve conservation at the California Channel Islands.

Discussion

Despite outcomes that included local community consensus statements regarding goals and objectives and the creation of one of the largest networks of no-take marine reserves in the world, this process contained potentially fatal flaws. Southern California is a large (more than 17 million people) and extremely diverse (172 languages) "local" community. Accurately and adequately representing this community in a 17-person, self-nominated and appointed working group may not have been possible. Many members of local fishing communities felt disenfranchised because they believed none of the working group members shared their ethnicity, fished in their fishery, or lived in their neighborhoods, despite the overwhelming representation on the working group by fishery interests.

The original process was conceived with a 1-year time line that was extended a full year to accommodate the learning process introduced by working with the science panel and socioeconomic team and to reduce pressure that may have forced confrontation rather than cooperation. As working group members learned through extended discussions and interactions with the expert panels and teams more about ocean science and economics and the likely outcomes of various reserve designs, they became further estranged from their purported constituents. Appointed by the Sanctuary Advisory Council, members of the working group were not officially selected by constituents and were only tenuously connected politically to other shareholders in the community at the outset of the process. The new concepts and knowledge of resource conditions and ecolog-

ical processes they learned during the process affected their decisions and compromises but exacerbated their community connections and strained communication.

Several working group members were paid executives of fishing or other industries and their jobs involved representing company or association positions. They may not have had complete freedom to negotiate forthrightly with other members without risking their jobs or to modify their positions in real time in response to new information or understanding developed during the process. Some members were either unable or unwilling to communicate what they learned to the various interest groups they represented. The working group received a letter at its last meeting, signed by more than 10 prominent leaders in one industry, angrily complaining that "their representative" on the working group had not represented their interests at all. Following the commission decision to create the network, several recreational and commercial fishing interests collectively filed a suit in state court for an injunction to stay implementation of regulations making the reserves effective, further evidence of a serious failure of communication and sense of exclusion from the process. The requested injunction was denied and the denial affirmed on appeal.

Another major, if not fatal, flaw was a disparity in the ecological and socioeconomic technical information available. Ecological decision support tools provided the working group with likely outcomes of various reserve network designs in terms of biodiversity conservation and other environmental factors. Economic data, however, could estimate only maximum possible losses based on past performance (fishery landings) from large geographic areas (34,080 ha). Some commercial fishers produced more precise landings data for analysis by the socioeconomic team. They considered these data proprietary and did not make them available to the public, so their accuracy, precision, and consistency could not be ascertained. This severely limited the value and perceived validity of the information. The lack of predictive economic models and inadequate data resulted in repeated comparisons of minimum likely environmental benefits of reserves with maximum possible economic losses. It also prevented any realistic means of accounting for the rapid declines in recent fishery landings in predicting future landings. When potential economic losses were calculated, all future landings were assumed to be constant at previous mean levels, even though it was clear they would not be because some fisheries had collapsed (abalone) and landings had declined recently for others (e.g., red sea urchins, rockfish, sea cucumbers, and California sheephead [Leet et al. 2001]).

The process did produce useful outcomes and provided several important lessons. Taken in the largest sense, the Channel Islands represent a useful example of large-scale environmental management with three adaptive cycles between 1938 and 2003. After protecting only habitat in

the 1930s and 1940s, adjustments were made in the 1960s to protect marine life too. Following nearly a decade of informal resource assessment, areas were then reopened to extraction in 1978. After monitoring for more than 20 years and exhausting numerous conventional fishery management strategies to sustain resources and fishing opportunities, public agencies and local communities again changed strategies to protect marine life in reserves in 2003. Science-based monitoring and research programs informed the latest decision process and continue to guide the new effort.

Allocating natural resources in the ocean and access to those resources in diverse communities is complex. It involves a combination of scientific knowledge and socioeconomic or political factors. Figure 2 shows how such factors may be arrayed along two axes to more clearly differentiate the underlying forces controlling their application to reserve design. Questions about minimum viable population sizes, representative habitats, biodiversity, and ecosystem integrity are largely informed by scientific inquiry. Questions of public value, fairness of allocations, equitability of risk and rewards, and conflicts among users are largely social and economic in nature, resolved by informed public policy. These social and economic factors may be shaped effectively by opinion and negotiation. To ensure community participation and support, all design factors should be addressed, but some are more important than others. Most of the questions about how much of what habitats and populations are needed to produce value are based on non-negotiable ecological principles of ecosystem structure and function. As Richard Feynman famously reminded us, "You can't fool nature." Science informs people about how nature works, but nature's structure and function are not the result of opinion polls or focus groups. Resource allocations may be based on negotiable social and economic values, but

they are dependent on biological productivity to have resources to allocate. Not understanding, integrating, or accepting the relationships among these various factors caused considerable confusion and disagreement during the working group's deliberations and left several members angry at the outcome.

Just as ecosystems in different parts of the world exhibit diverse characteristics and just as scale in ecosystems is critical to understanding their dynamics and behavior (Dayton & Tegner 1984), so it is with human systems. Social processes used successfully to arrange resource allocations and to create marine reserves in small, remote Philippine villages, where a few hundred people speak the same language and share a common heritage, are not likely to work well in larger, more culturally diverse communities such as the Florida Keys, where thousands of people speak several languages and seek a wide variety of cultural values from the sea (Suman et al. 1999; Alcalá & Russ 2003). Similarly, the social processes used in the Florida Keys may not work well in southern California, where more than 17 million people from more than 150 cultures share access to the sea. Effective communication among "local" community members varies dramatically in each of these examples, from family discussions to mass media. Collective decision making becomes more formal as the size and complexity of the communities increase. It is unlikely that there is a "one process suits all" solution to addressing the complex, human side of place-based ocean conservation.

Conclusion

Aldo Leopold's land ethic obliges people to honor ecological processes. That ethic pertains equally well to the sea. This ethic also obliges people to honor the process

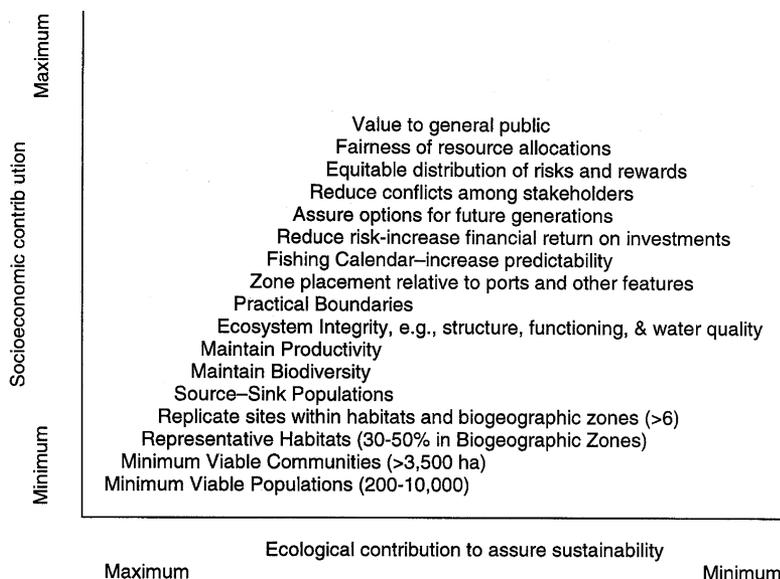


Figure 2. Reaching consensus on marine reserve designs was facilitated by differentiating the relative non-negotiable ecological (x-axis) and negotiable socioeconomic contributions (y-axis) of factors critical for achieving and sustaining desired values and goals in nearshore marine environments at the California Channel Islands.

in social contracts: to ensure the steps we take toward our shared goals do not so damage human relationships that we fail to reach our goals. As stewards of the sea, we enter into a covenant with one another and with the millions who will follow us. This generation is obligated to leave a legacy of hope and of opportunity for those who follow. The damage done to human relationships by the Channel Islands process may produce pyrrhic victories for all. The Channel Islands reserve network is a pioneering effort so abhorred by some in the fishing community that it led to a stalemate in statewide efforts to restore California's once-productive ocean that has yet to be overcome. The Channel Islands process provides a cautionary tale about the pitfalls of consensus-seeking in large, complex communities by quasi-representational groups and the value and power of science-based decision making. It is a hopeful situation because collective, science-based, community-supported decisions were made to begin resource restoration and to explore a new social contract. If successful, this generation of people will have preserved options to enjoy the sea for the next generation that were nearly lost forever.

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