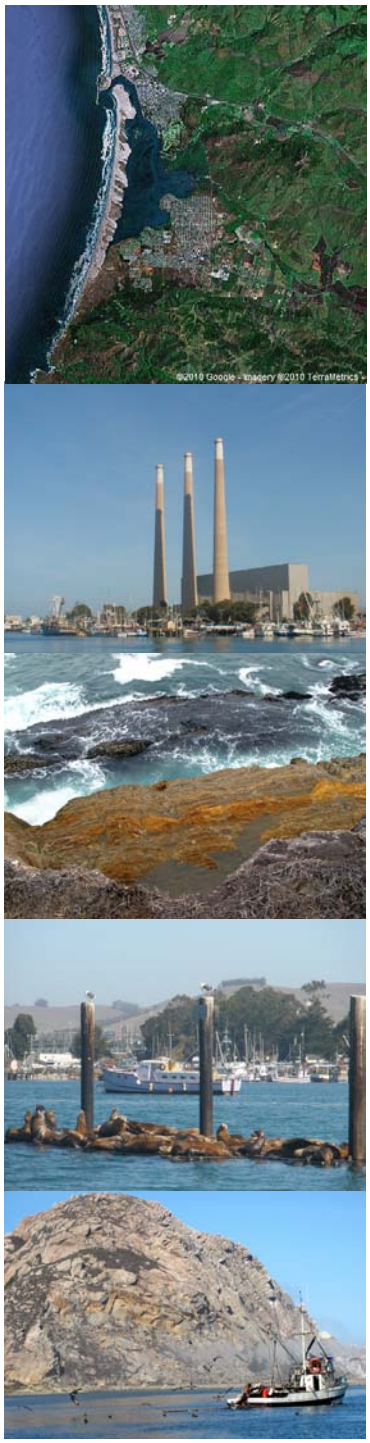

Brown University

San Luis Obispo Science and Ecosystem Alliance

A Case Study of Marine Ecosystem-Based Management

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About the Study

Recognizing the declining health of the world's oceans, policymakers, managers and scientists have called for expanded efforts at ecosystem-based management in marine and coastal systems (MEBM). In many places in North America and around the world, collaborative, adaptive planning and management processes have developed to enable scientists, managers and stakeholders to move beyond management of single species and single user groups to incorporate complexity, consider larger scales and longer timeframes, and incorporate measures of ecosystem integrity.

The David and Lucile Packard Foundation invested in the development of science to support management in a number of initiatives in California, Mexico and the Western Pacific. The Foundation also recognized the need to capture the lessons from the experiences at these initiatives as well as the many other places that are trying to move toward an ecosystem-based management approach. Accordingly, they provided grant support to research teams at the University of Michigan and Brown and Duke Universities to develop rich case studies of MEBM, documenting the approaches and their accomplishments, and analyzing the challenges the efforts faced and the factors that have promoted progress. Ultimately, the projects seek to provide lessons that can improve the practice of MEBM.

This document contains one of the complete case studies. Others can be accessed through the project website, which can be reached at: *www.snre.umich.edu/ecomgt/mebm*.

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Introduction

The Morro Bay estuary is a rare and important ecosystem on the central California coast. It has been designated as a member of the Environmental Protection Agency's National Estuary Program, and in conjunction with its surrounding watershed, this system is home to over 250 species of wildlife. The estuary itself provides a variety of invaluable ecosystem services, including critical feeding grounds for migratory birds, nursery areas for local fisheries, and abundant recreational opportunities for residents and visitors, to name a few. While the area is considered to be relatively healthy, pollution, habitat degradation, climate change and other issues threaten the system's water quality, wildlife and local economy.

Complementing existing efforts in the area, in 2006, the San Luis Obispo Science and Ecosystem Alliance (SLOSEA) was established in Morro Bay to improve environmental management of the area's resources by enhancing communication and collaboration among isolated institutions and coordinating their fragmented activities within the Morro Bay estuary, watershed, and coastal ocean. Aiming to harmonize research efforts and resource management decisions, and improve ecosystem conditions, SLOSEA formed a multi-stakeholder Advisory Committee that integrates the strengths and resources of two local grassroots stakeholder groups with local academic scientists, regulatory agencies, environmental groups and representatives of various community interests.

Since its inception, SLOSEA has brought sound science to questions of interest to local resource management agencies and others living in the area. For example, scientists affiliated with SLOSEA have conducted experiments to assess the impacts of human access on intertidal areas. The results of these studies helped to inform management decisions at the California Department of Parks and Recreation. Also, scientists affiliated with SLOSEA discovered a high incidence of nonylphenol, an industrial chemical, in the sediment and water in the bay, which has been linked to tumors in resident fish. Through partnerships forged by the SLOSEA Advisory Committee, this discovery has led to activity at the regional, state and national levels to better regulate this chemical. In addition, SLOSEA has worked in collaboration with fishermen to develop a monitoring protocol for nearshore fishery stocks, which is being used to correct data issues for fisheries management, enhance efforts to encourage regional fisheries management and evaluate effectiveness of recently established marine protected areas (MPAs). SLOSEA and partners are also pursuing policy changes to allow local data collected via this protocol to inform the setting of catch limits for regional fisheries.

Ecosystem Characteristics and Stressors

Ecological Context

Estuaries are uncommon along the coast of California, which makes Morro Bay a unique and valuable natural resource. The estuary itself is a 2,300 acre (9.3 km^2) semi-enclosed body of water that empties into the larger Estero Bay, halfway between San Francisco and Los Angeles (Figure 1). It is comprised of approximately 330 acres (1.3 km^2) of eelgrass (*Zostera marina*), which provide nursery areas for fish such as rockfish and halibut (*Paralichthys californicus*), comprises an important food resource to migratory birds and improves water clarity and quality; 1,200 acres (4.9 km^2) of mudflats, which are critical habitat for several flatfish species, invertebrates such as the white bubble snail (*Haminoea vesicula*) and green shore crab (*Hemigrapsus oregonensis*), and many bird species; 380 acres (1.5 km^2) of salt marsh; 175 acres (0.7 km^2) of subtidal habitat; and a small amount of emergent rocky substrata (Sneed, 2006; Duff, 2006; Environmental Protection Agency [EPA], 2007; San Luis Obispo Science and Ecosystem Alliance [SLOSEA], 2008; Wendt, Pendleton, & Maruska, 2009; Central Coast Wetlands Group [CCWG], 2004; San Luis Obispo Science and Ecosystem Alliance [SLOSEA], n.d. a).

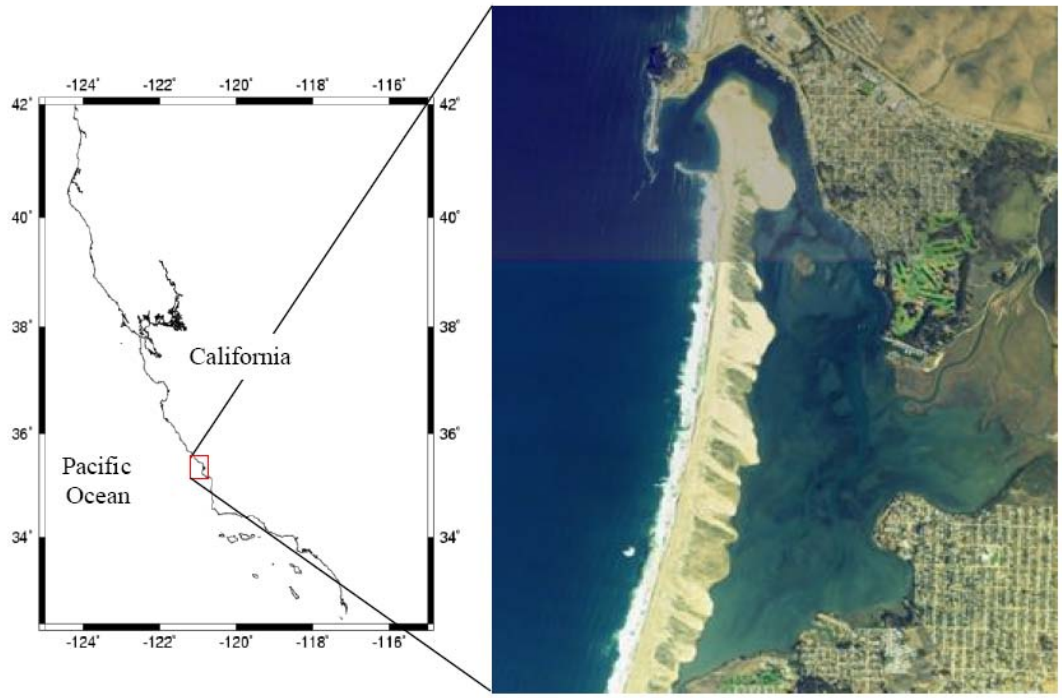

Figure 1: Map indicating the location of the Morro Bay estuary on the central California coast, equidistant from San Francisco and Los Angeles (Wendt, 2006a).

Because the watershed empties into an embayment rather than directly into the ocean, it exhibits strong land-sea interactions (Wendt, 2006a; Wendt et al., 2009). The ecosystem continuum is perhaps best exemplified by the life cycle of the steelhead trout (*Oncorhynchus*

mykiss), an anadromous salmonid that hatches and grows in the freshwater streams of the watershed before migrating to the ocean to forage and mature (Resource Manager[1], personal communication, September 2009). After several years at sea, it returns to its natal freshwater creeks and streams to spawn and lay eggs.

The iconic steelhead trout is one of several federally listed species that reside in the watershed, estuary, and/or nearshore ocean, which together comprise the "Morro Bay ecosystem". Of the 250 species of wildlife that reside here, sixteen are threatened or endangered species (e.g., tidewater goby (*Eucyclogobius newberry),* the western snowy plover (*Charadrius alexandrines nivosus),* and California black rail (*Laterallus jamaicensis coturniculus*)) and six are endemic to the area (i.e., the Morro Bay kangaroo rat (*Dipodomys heermanni morroensis*), California sea-blite (*Suaeda californica*), Chorro Creek bog thistle (*Cirsium fontinale* var. *obispoense*), indian knob mountain balm (*Eriodictyon altissimum*), Morro manzanita (*Arctostaphylos morroensis*), and Morro shoulderband snail (*Helminthoglypta walkeriana))* (Budge, Clark, Hunter, Mcgovern, & Wilson, 2000; Wendt, 2006a; Wendt et al., 2009; Morro Bay National Estuary Program [MBNEP], 2006; Morro Bay Chamber of Commerce & Visitor Center, 2009).

The watershed itself is a 48,000 acre (194.2 km^2) drainage basin comprised of oak woodlands, grasslands, coastal chaparral, coastal dunes, coastal sage, riparian corridors and two main tributaries, the Los Osos and Chorro Creeks (SLOSEA, 2008; Wendt et al., 2009). The shoreline areas of Morro Bay consist of some of the largest coastal dunes in the state along with sections of sandy beach and rocky intertidal habitats (SLOSEA, 2008). These coastal habitats provide breeding and feeding grounds to numerous species of bird; marine mammals such as sea otters (*Enhydra lutris*); invertebrates such as abalone, mussels, sea stars, limpets, crabs and sea anemones; and a variety of algal species (SLOSEA, 2008).

Nearshore subtidal areas accommodate sandy and rocky reefs, subtidal and intertidal benthic habitats, and extensive kelp beds are found north and south of the bay (Duff, 2006). Invertebrates such as crabs, sea cucumbers, sea urchins and clams, and numerous fish species such as the California halibut inhabit sandy reef habitats (SLOSEA, 2008). Several species of rockfish, abalone, sea urchins, marine mammals and algae are found in shallow rocky-reef areas (SLOSEA, 2008). Other noteworthy species found within the Morro Bay ecosystem include mammals such as California sea lions (*Zalophus californianus*) and whales; resident and migratory birds such as brown pelicans (*Pelecanus occidentalis*) and white pelicans (*Pelecanus erthrorhynchos*), peregrine falcons (*Falco peregrinus*), herons, and Brandt geese (*Branta bernicla*), which are dependent upon these critical feeding areas during migratory stopovers; infaunal organisms that are found only in estuaries; and resident and migratory fish such as lingcod (*Ophiodon elongates),* cabezon (*Scorpaenichthys marmoratus*), flatfish (i.e., halibut, flounder and sole), and albacore tuna (*Thunnus alalunga*), salmon, and steelhead trout (Sneed, 2006; Duff, 2006; SLOSEA, 2008; Wendt et al., 2009).

[1] To protect the identity of interviewees, names have been removed and replaced with titles that indicate their general role in the project.

The area's biodiversity can be attributed to its diverse habitats, high productivity and relatively pristine condition. The high productivity is a consequence of one of the strongest upwelling zones in California that is located just off the coast of Morro Bay (Duff, 2006). Upwelling currents of nutrient-rich waters nourish the region's spectrum of resident and transient species via trophic interactions (Duff, 2006).

Social and Economic Context

Approximately one third of the watershed is publicly owned, including the Morro Bay State Park, Chorro Valley County Park, Los Padres National Forest and the US National Guard facility at Camp San Luis. The remaining two thirds are privately owned with a majority of the land in some form of agricultural production (approximately 68%), primarily medium to large cattle ranches and farms (Duff, 2006; Wendt et al., 2009). Limited amounts of urbanization (approximately 11%) can be found in the residential and commercial areas of Los Osos and Morro Bay, the watershed's two towns that have an approximate combined population of 25,000 people (Duff, 2006; Wendt et al., 2009).

Communities in the area have depended upon coastal resources and a working waterfront for over 130 years. However, over the last few decades, the nature of businesses along the waterfront and their relative contribution to the local economy has changed. As the only all-weather port between Monterey and Santa Barbara, approximately 200 miles (321.9 km) of coastline, the Morro Bay/Port San Luis area is a regional harbor facility that was historically dominated by commercial and party boat fishing industries (SLOSEA, 2008; Resource Manager, personal communication, September 2009). Although once thriving, these industries have recently downsized as a result of more stringent resource management regulations. These changes, which were precipitated by legislative mandates and shifts in the public's expectations, have caused the fishing industry in the area to decline, many fishing vessels have now been sold and businesses that once supported the fishing industries such as chandleries, marine ice vendors, and sport fishing operations have shut down (Wendt et al., 2009). Concurrent with these changes, over the last twenty years, the harbor district's primary activities have shifted from harbor patrol, water rescue and maintaining facilities for boater services, to more resource stewardship responsibilities, including habitat and wildlife conservation and management, pollution prevention and water quality management (Stakeholder, personal communication, September 2009).

Today, recreational and commercial fishing operations comprise only a small fraction of the local economy and tourism now plays a more significant role. With 1.5 million visitors coming to Morro Bay per year, nature-based sight-seeing and recreational opportunities such as bird watching, beach-going, kayaking, swimming, boating/sailing, hiking, mountain biking, off-road driving, hunting, surfing, tide pooling and horseback riding now dominate the waterfront (EPA, 2007). Land-based agriculture (i.e., farming and grazing), active oyster and abalone aquaculture industries, two golf courses, several state parks and a natural gas-fired power plant also contribute to the local economy (SLOSEA2008; Wendt et al., 2009; CCWG, 2004).

Ecosystem Threats

The Morro Bay estuary, watershed, and coastal ocean support a variety of "beneficial human uses", all of which depend on a healthy ecosystem (Morro Bay National Estuary Program [MBNEP], 2000). However, the area's resources, ecosystem services, and marine economy are impacted by a suite of factors. Stressors to the system include increasing sedimentation rates and pollution (point and non-point source) from upland areas, which are reducing open water habitat and degrading water quality in the bay, respectively; modified freshwater flows, which are altering wildlife habitat in the watershed; fragile intertidal habitats are being degraded through unintended impacts of human access; invasive species are causing changes in the composition of the fouling community in the bay; poor fisheries management is affecting the local economy; and climate change promises to raise sea-level and potentially compromise efforts to address the other threats just listed (Sneed, 2006; Wendt et al., 2009). In addition to impacting wildlife and environmental aspects of the ecosystem, these threats are endangering ecosystem services provided by the system and the quality of life and livelihoods of the people living nearby.

First, row crop agriculture and intensive ranching taking place throughout the watershed are causing upland erosion and subsequent sedimentation of the estuary. As a result, predictions have been made that the open water areas of the bay will fill in within the next 300 years (SLOSEA, 2008; Wendt et al., 2009). Within the last 100 years, 25% of the bay's volume has been lost to sedimentation (Wendt et al., 2009).

Second, point and non-point source pollution resulting from leakage of cleaning products and other substances built up in septic tanks, run-off of nutrients such as pesticides and fertilizers from land-based activities, and inputs of partially treated sewage are responsible for poor water quality in the bay. Three of the most notable water quality issues in the area include the presence of fecal coliform bacteria in the bay that is possibly leaking from the city of Los Osos' 4,300 septic systems and has led to area closures for recreational uses and oyster farming; the recently discovered presence of the pollutant nonylphenol, which is used in the polymer and detergent industries, in sediment, water and organisms in the bay; and eutrophication, which causes large benthic algal blooms and subsequent periods of hypoxia (SLOSEA, n.d. b). In addition, the towns of Morro Bay and Los Osos discharge partially treated sewage 0.5 miles (0.8 km) offshore in Estero Bay (Wendt et al., 2009).

Third, freshwater withdrawal for row-crop agriculture and cattle ranching is diminishing freshwater flow in the watershed, which reduces the availability of critical riverine habitat required by steelhead trout for spawning and migration corridors to the ocean (SLOSEA, 2008).

Fourth, eighteen miles (29 km) of coastal property in San Luis Obispo County were recently acquired by the California Department of Parks and Recreation (State Parks) and opened to the public. Increased foot traffic and harvesting of intertidal organisms may degrade sensitive intertidal areas and lead to over exploitation of some species (SLOSEA, n.d. c).

Fifth, it has been recognized that non-native species are reaching Morro Bay on the hulls of ships, and after arriving, they thrive on the area's rich upwelling coastal waters (SLOSEA, n.d.

d). Once established, these invasive species interrupt native species' food supply and upset the local economy by impairing such infrastructure as pier pilings, industrial buildings and equipment (SLOSEA, n.d. d). While the ratio of native and introduced species in the estuary has remained relatively constant over the last three decades, invasive species have caused major shifts in the composition of the fouling community, moving the system from a native mussel-dominated community to a community dominated by an invasive bryozoan species, *Watersipora subtorquata* (Needles, 2007). This transition is affecting native species and is having ecosystem-wide consequences due in part to the loss of water filtration services previously provided by the native mussel.

Sixth, the unsustainable exploitation of nearshore fishery species in offshore waters north and south of the bay has led to areas closures and reduced catch limits relative to ten years ago (SLOSEA, 2008; Wendt et al., 2009). Also, temporal closures have been instated for all recreational fisheries and some commercial fisheries during certain times of the year (SLOSEA, 2008; Wendt et al., 2009). These closures have handicapped the fishing industry in Morro Bay, and because fisheries managers base catch limits and area closures on sparse, state-scale data, management decisions are not made in light of local resource conditions that are perceived to be more robust than elsewhere in the state. In fact, a recent analysis seems to indicate local nearshore fish may not have experienced the same declines found elsewhere (Stephens, Wilson-Vandenberg, Carroll, Nakamura, Nakada, Rienkeke, & Wilson, 2006). Without considering locally-derived data regarding fish stocks when setting fishery regulations, fisheries management agencies will continue to make poorly-informed management decisions that affect local fishermen and the sustainability of this industry in local economy.

Lastly, climate change threatens to raise sea level and further impair water quality, which means plans to manage resources and habitats in Morro Bay need to be re-evaluated in light of potential long-term ecosystem transformations.

These stressors are also acting in combination with one another, further complicating efforts to enhance habitats, resources, and ecosystem services in the Morro Bay ecosystem. The oyster culture industry is one of the most impacted economic sectors in Morro Bay and serves as an example of the additive impacts of these factors on the community. Over the last 25 years, oyster production in the bay has been declining. This is due to a combination of fecal coliform bacteria contamination of the bay, increasing sedimentation and the reestablishment of eelgrass habitat (Wendt et al., 2009). Currently, due to unpredictable, intermittent spikes in fecal coliform bacteria, harvesting oysters is prohibited in more than half of the 760 acres (3.1 km^2) that were designated for oyster culture in 1988 (Baltan, 2007). Also, increasing sedimentation is making the estuary shallower and impairing water quality, and eelgrass is becoming reestablished in the bay, further reducing the area available for oyster culture (Wendt et al., 2009). Eelgrass provides several important ecosystem services, which have led to its designation as a protected species. Therefore, it can't legally be disturbed by shading or activities that impact the benthic community such as oyster culture (Wendt et al., 2009). The dampened productivity of this industry combined with the dwindling offshore fishing industry has reduced economic opportunities in the area, which makes Morro Bay more dependent on tourism, which is itself sensitive to ecosystem conditions.

EBM Initiative

Before the San Luis Obispo Science and Ecosystem Alliance (SLOSEA)

Prior to initiation of the EBM effort in Morro Bay, "regional efforts to conduct science and manage the resources [were] fragmented within narrowly defined elements of the ecosystem (e.g., land/estuary vs. coastal habitats, conservation vs. economic concerns) and driven by isolated institutions (e.g., local governments, State Parks, Coastal Commission, Fish and Game, Regional Water Quality Control Board)" (SLOSEA, 2008). As a result, managers and others in the area lacked "a fundamental understanding of (1) the true boundaries of the ecosystem (i.e., from land to sea) and (2) which aspects of the ecosystem are the critical linking factors (i.e., nutrients, sediment, species, etc.)" (Wendt, 2006a). This limited knowledge of the ecosystem impaired managers' "ability to plan and take coordinated and concerted conservation and management actions" (SLOSEA, 2008). Also, mechanisms for linking relevant local science with decision-making processes were nonexistent, which diminished opportunities to ensure management decisions were well-informed and had the potential to ensure long-term maintenance of healthy and productive conditions in the Morro Bay ecosystem (SLOSEA, 2008).

Two local entities, the Morro Bay National Estuary Program (MBNEP) and the Marine Interests Groups of San Luis Obispo County (MIG), were well established local non-profit groups that were doing elements of ecosystem-based management - engaging stakeholders, monitoring resources, pursuing conservation and working towards sustainable use of Morro Bay's resources; however, "each […] concentrates on different geographical areas of the ecosystem" (Wendt, 2006a), and it does not appear they interacted much. In addition, important agencies such as the California Department of Fish and Game (DFG) and Department of Parks and Recreation (State Parks) were not formally represented in either the MBNEP or MIG despite their overlapping jurisdictions in the area (Duff, 2006).Therefore, the MBNEP and MIG's activities took place largely "in isolation of these key resources agencies" (Duff, 2006). In addition, scientists at California Polytechnic State University (Cal Poly) were not yet fully engaged with these groups despite their potential to make valuable scientific contributions.

The Morro Bay National Estuary Program (MBNEP) is a local collaborative organization established in 1995 as a member of the Environmental Protection Agency's National Estuary Program (NEP) that is run through the Office of Water. Its membership in the NEP was catalyzed in 1994 by grassroots efforts of local citizens who lobbied for recognition of the estuary's importance at the state and federal level. In 1994, Morro Bay was designated California's first State Estuary before its acceptance into the NEP the following year (Wendt, 2006a). Through its Board of Directors and various committees, the MBNEP works collaboratively with government representatives, resource management agencies, interest groups, land owners and other local stakeholders. It does not, itself, possess regulatory authority (Wendt, 2006a). The goals of the MBNEP are to:

(1) Slow the process of bay sedimentation through implementation of management measures, which address erosion and sediment transport.

(2) Re-establish healthy steelhead trout habitat in Chorro and Los Osos creeks through measures, including reduction of sediment loading in gravels, stabilization of riparian corridors, removal or mitigation of barriers, improvement of water quality, and restoration and maintenance of adequate freshwater flow.

(3) Ensure the bay water remains of sufficient quality to support a viable commercial shellfish mariculture industry, safe recreational uses, healthy eelgrass bed and thriving fish and shellfish populations.

(4) Ensure the integrity of the broad diversity of natural habitats and associated native wildlife species in the bay and watershed.

(5) Maintain watershed functional integrity through appropriate riparian corridor management, impervious surface management, fire management and grazing management.

(6) Protect social, economic and environmental benefits provided by the bay and watershed, including agriculture and fisheries, through comprehensive resource management planning.

(7) Promote public awareness and involvement in estuarine management issues through outreach, educational programs and the use of volunteers in ongoing bay monitoring and other programs. (MBNEP, 2000)

The Marine Interests Group of San Luis Obispo County (MIG) was formed in 2003 as a multi-stakeholder consensus group supported by the World Wildlife Fund and assembled at the request of the county supervisors to discuss the possibility of expanding the Monterey Bay National Marine Sanctuary into coastal waters along the coast of San Luis Obispo County. This group, comprised of fishermen, business people, the Chamber of Commerce, environmental groups and others, was initially considering the expansion of the sanctuary as a means to protect Estero Bay from dumping of selenium-tainted agricultural waste from the San Joaquin Valley, a management option put forth by the Bureau of Reclamation. The group ultimately decided against the expansion of the sanctuary, but has since continued to convene on matters of local marine interests, including the enhancement and maintenance of nearshore resources and their use and enjoyment by community members and visitors. The organization's official statement of purpose is to:

(1) Promote understanding of the marine resources off the Coast of San Luis Obispo County and the needs and interests of the stakeholders involved with their use and enjoyment;

(2) Openly examine potential ways to sustain and enhance the resources; and

(3) Recommend desirable courses of action (or no-action) as appropriate to support the resources and their sustainable use. (Wendt, 2006a)

Establishment of SLOSEA

Recognizing the need to integrate the activities, resources and knowledge of the MIG and MBNEP with the scientific capacity of Cal Poly and government agencies with authority over the land and resources in the area, a scientist from Cal Poly along with the Director of the MBNEP and professional facilitator of the MIG elicited the participation of a variety of stakeholders and formed the San Luis Obispo Science and Ecosystem Alliance (SLOSEA) in 2006. At this time, The David and Lucile Packard Foundation (Packard Foundation) awarded a planning grant to Cal Poly to support the development of a comprehensive ecosystem-based management (EBM) program proposal for the organization. The finished proposal was awarded funding from the Packard Foundation along with grants from the Resources Legacy Fund Foundation and World Wildlife Fund. With these funds in place, SLOSEA's first strategic plan was developed, involving collective input from 35 people on the SLOSEA project team (SLOSEA, 2008).

SLOSEA Goals and Objectives

SLOSEA was established to integrate scientific and management communities and stakeholders across the ecosystem and achieve its collective vision "for a healthy, resilient coastal ecosystem that provides for thriving and interacting populations of plant, animal and human communities" (Wendt, 2006a; SLOSEA, 2008). Overall, the SLOSEA program is:

> Working with the MIG and MBNEP to build on their existing strengths and to overcome previous limitations by conducting research and monitoring over spatial scales that complement what the other organizations do and by establishing an integrated, cross-jurisdictional management community for the entire Morro Bay ecosystem (land, estuary and coastal ocean). (Wendt et al., 2009)

The first phase of SLOSEA's EBM activities, entitled *Elucidating the Nexus of Science and Society in the Morro Bay Ecosystem,* lasted from 2006-2008 and focused on building relationships among participants, establishing itself as a functional organization and conducting user-driven science. In the beginning, its broad objectives were:

(1) To develop and monitor relevant physical/chemical, biological and socioeconomic indicators across the ecosystem and to determine how the various components are interconnected and how they affect on another;

(2) To establish a clear understanding of the institutional linkages within the ecosystem and to build and reorganize the "institutional ecosystem" where needed;

(3) To provide managers and stakeholders with improved ecological and sociological data for shared deliberation and decision making on an ecosystem-wide basis for maximum impact and cost effectiveness; and

(4) To develop a model for EBM that can be utilized in other areas of California, the nation and the world. (Wendt, 2006a).

SLOSEA established an Advisory Committee with representatives of the MBNEP, MIG, Cal Poly, Regional Water Quality Control Board, California Coastal Commission, State Parks, DFG, City of Morro Bay, US Fish and Wildlife Service, National Oceanic and Atmospheric Administration (NOAA) Fisheries Department, the Morro Bay Harbor District and other ecosystem interests. Together, this group identified top priorities that could be effectively pursued with its existing resources. These issues included the conservation of sensitive coastal habitats throughout the ecosystem, preservation of native wildlife populations, management of coastal water quality, promotion of strongly supported fishing communities and fishery resources such that these resources can be harvested on a continual basis, and restoration and enhancement of a flourishing marine economy that provides diverse job opportunities and services to the local community (SLOSEA, 2008; SLOSEA, n.d. c). The areas of interest were then developed into initiatives with clearly articulated objectives, deliverables and management values. Finally, in an iterative process, resource managers and scientists aligned knowledge gaps and information needs with relevant methodologies to ensure the research conducted would help managers make sound management decisions.

SLOSEA Initiatives

SLOSEA's initiative areas include the habitat initiative, human access initiative, water quality initiative, bioindicators initiative, economic indicators initiative, and collaborative fisheries initiative[2] (Wendt et al., 2009). These six initiatives are all incorporated under the umbrella initiative, science and management linkages, which strives to interpret and combine the results generated within the other initiatives into "Management Action Memos" that are disseminated to policy-makers and management agencies (SLOSEA, n.d. e).

The broad goal of the habitat initiative was to "determine the relevant extents, distributions, and characteristics of critical spawning and nursery areas for fish and invertebrate species in the 'Morro Bay Ecosystem,'" and "determine the importance of the bay/estuary as a nursery environment for coastal species of fish and invertebrates" (Wendt, 2006a). In particular, the proportion of California halibut produced within the estuary is being determined to establish the estuary's significance for this commercially important species (SLOSEA, n.d. f). Activities under this initiative are also leading to the development of high resolution (1-3 m grid) GIS bathymetry and habitat maps (SLOSEA, n.d. f). Also, the distribution of seasonal and resident fish species are being identified and mapped along with information about available habitats (SLOSEA, n.d. f).

The broad goal of the human access initiative was to "determine the effects of human uses on marine biological communities in the Morro Bay Estuary and associated coastal habitats" (Wendt, 2006a). More specifically, it was intended to provide information that could inform the State Parks on management of eighteen miles (29 km) of recently acquired pristine coastal

[2] This is current as of January 2010. Since that time, some of the initiatives have been reorganized - some combined or changed names, others may have ended and new ones have emerged. See www.slosea.org for an update list of initiatives.

property. Areas of the bay and nearby coastal habitats were evaluated regarding their susceptibility to impacts caused by trampling and harvesting of intertidal organisms (SLOSEA, n.d. g), and then, scientists and student researchers at Cal Poly conducted experiments to compare the range of natural variability in these habitats with a range of simulated human impacts (SLOSEA, n.d. g). The results of these studies are helping to identify appropriate levels and types of human use in these areas (SLOSEA, n.d. g).

The broad goal of the water quality initiative was "to determine the spatial and temporal changes in physical and chemical characteristics of water quality in the 'Morro Bay Ecosystem,'" and "to identify the importance of both natural and anthropogenic sources in causing those changes so as to improve management and policy actions" (Wendt, 2006a). Four Land/Ocean Biogeochemical Observatory (LOBO) water quality monitoring stations were installed throughout Morro Bay, with an additional station in Estero Bay. These stations measure conductivity, temperature, pressure, dissolved oxygen, oxygen saturation, fluorescence, turbidity, and nitrate in the water (SLOSEA, n.d. h). Some stations also have the ability to measure water currents, which will help scientists further understand the spatial and temporal dynamics of the bay (SLOSEA, n.d. i). Information generated under this initiative is being provided to the representatives of relevant regulatory agencies.

The broad goal of the biological indicators (bioindicators) was "to develop and utilize representative bioindicators to monitor and track changes in ecosystem health," and "to determine the dynamics and response of secondary production in the 'Morro Bay Ecosystem'" (Wendt, 2006a). The bioindicators initiative is developing a list of species that respond to fluctuations in ecosystem conditions via changes in protein expression. These species (California mussel (*Mytilus californianus*) and oyster (*Crassostrea gigas*)) can be used as metrics of ecosystem health. These organisms' responses can be correlated with data from the water quality initiative to identify possible relationships (SLOSEA, n.d. j). Tracking indicators also helps scientists understand population and community responses to changes in secondary production in the bay (SLOSEA, n.d. j).

The broad goal of the socio-economic indicators initiative was "to determine how ecological health influences the economic wellbeing of people who live near and make a living from the Morro Bay estuary and near shore ecosystem" (Wendt, 2006a). A database is being established for socio-economic indicators and a baseline status of economic activity within the bay and coastal ocean areas is being elucidated (SLOSEA, n.d. k). On an annual basis, indicators are measured and analyzed, thus providing a chronicle of changes and enabling recognition of patterns of economic output (SLOSEA, n.d. k). Eventually, this data will be integrated into a model that will advance understanding of the connections between economic activities, ecosystem productivity, and the health of the ecosystem (SLOSEA, n.d. k).

The collaborative fisheries initiative began as the California Collaborative Fisheries Research Program (CCFRP), which was established in 2007 as a joint effort between the Cal Poly Center for Coastal Marine Sciences, the Moss Landing Marine Laboratories and the fishing communities in Half Moon Bay, Monterey, Morro Bay and Port San Luis to increase understanding of the health of local fish stocks and the marine ecosystems which they inhabit

through collaborative research that enlisted the expertise of fishermen and scientists alike (SLOSEA, n.d. l). The initial objectives of the Collaborative Fisheries Research Project were to:

(1) Develop rigorous scientific protocols to monitor central California MPAs;

(2) Engage the fishing community in the monitoring of MPAs;

(3) Evaluate differences between MPAs and reference sites at the time of closure;

(4) Generate baseline data for future evaluation of changes in species and size composition and relative abundance of fishes associated with shallow rock habitats inside and outside MPAs; and

(5) Create a sampling design that can be used to collect data for state and federal stock assessments. (Starr, Wendt, Yochum, Green, Longabach, Leary, Lemon, Mattusch, Rocha, & Selck, 2008).

In 2008, SLOSEA underwent a second strategic planning process, which commenced the second phase of its effort, entitled *Translating SLOSEA Science into Management Actions*. During this phase, which will last through 2011, SLOSEA is focusing its activities on:

- Addressing key pollutant sources and impacts;
- Building data and framework for regional fisheries management;
- Guiding appropriate levels of human access;
- Identifying, detecting and controlling marine invasives;
- Informing decision-making for a diversified marine economy; and
- Characterizing climate change effects and prioritizing local actions. (SLOSEA, 2008)

SLOSEA has identified the following eight conservation targets: watersheds, estuarine systems, shoreline habitats, nearshore subtidal areas, iconic species, marine invertebrates, finfish and the working bay/port system (i.e., marine economy) (SLOSEA, 2008). According to the Open Standards for the Practice of Conservation outlined by the Conservation Measures Partnership used by SLOSEA during its strategic planning process, "Conservation of these targets will ensure conservation of all native biodiversity within functional landscapes" (SLOSEA, 2008).

Boundaries

Initially, the boundaries of SLOSEA's EBM effort were vague and included the Morro Bay estuary, encompassing watershed, and nearshore coastal ocean. However, in 2008, during the second strategic planning process, SLOSEA articulated more specific boundaries based on the distribution of its initiatives' activities and conservation targets (Scientist, personal communication, September 2009). The boundaries now include the Morro Bay estuary,

nearshore coast (to 100 fathoms) and associated watersheds from Point Lopez in the north to Point Conception in the south (Figure 2). This area was delineated based on ecological and social "boundaries" in the south (i.e., a biogeographic transition and the southern extent of local fishing fleets' range, respectively), a jurisdictional boundary for the DFG in the north, watershed boundaries to the east, and an ecological boundary delineating fish communities in the west. The new geographic scope includes 42 coastal watersheds, and in addition to accommodating the full scope of SLOSEA's activities, the expansion of SLOSEA's boundaries also acknowledges reports that recognize these watershed areas as globally significant hotspots of terrestrial biodiversity (SLOSEA, 2008; Wendt et al., 2009). Furthermore, recently published scenarios for climate change have identified these watersheds as expected refugia for numerous plant species that will be threatened by reductions in their current ranges (Loarie, Carter, Hayhoe, McMahon, Moe, Knight, & Ackerly, 2008; SLOSEA, 2008).

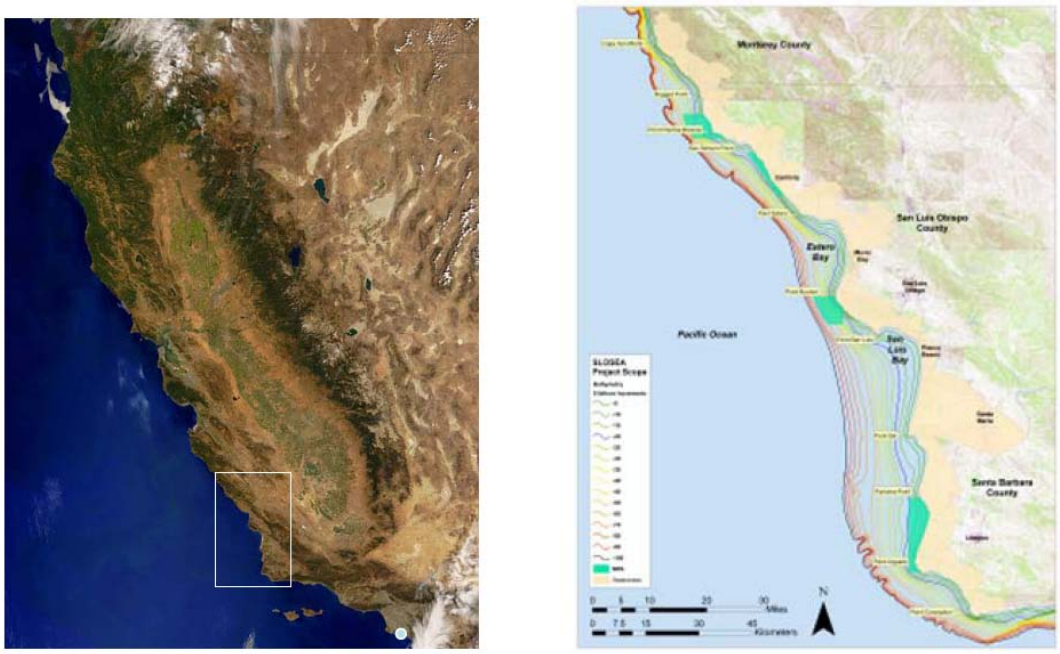

Figure 2: Aerial image (left) indicates the location of the map (right), which shows the scope of SLOSEA's activities and focus (SLOSEA, 2008).

Organizational Structure

SLOSEA is comprised of three primary groups: the Advisory Committee, the Leadership Team, and the Science Team (Figure 3) (Wendt et al., 2009). In all, there are approximately 41 SLOSEA project team members: five Leadership Team members, seven Science Team members, 18 Advisory Committee members and 11 SLOSEA partners (SLOSEA, 2008). Together they develop and execute SLOSEA's strategic plan, and working groups comprised of SLOSEA members collaborate to lead, organize and implement activities in each initiative area. SLOSEA's authority is limited to SLOSEA initiatives and activities while authority to make resource and land management decisions remains with respective government agencies.

The Advisory Committee is SLOSEA's primary governing body, comprised of representatives of organizations with jurisdictional authority and management responsibilities in the ecosystem, stakeholders that live and work in the ecosystem, and three individuals from the Science Team. This group forms the "integrated ecosystem group" (Wendt et al., 2009). Responsibilities of the Advisory Committee include developing areas for scientific investigation; reviewing research objectives, methods and results; ensuring data products are linked with resource management decision-making processes; and providing an environment in which participating agencies and stakeholders can share information and develop collaborative relationships (SLOSEA, 2008; Wendt et al., 2009). This committee historically met on a quarterly basis, but recently reduced the frequency of its meetings because of funding limitations and the reduced need for them due to the current stage of implementation.

The SLOSEA Leadership Team includes the SLOSEA Program Director, SLOSEA Program Coordinator, the Director of the Morro Bay National Estuary Program, a Marine Policy and Communications Manager, and a Strategy and Fisheries Policy Advisor (Wendt et al., 2009). The role of the Leadership Team is to provide oversight and direction for the EBM effort and to ensure strong, coherent connections are made between scientific research and management. This team meets on an as-needed basis (SLOSEA, 2008).

The Science Team is comprised of academic and agency scientists and associated research staff members (Wendt et al., 2009). This group's main responsibilities are to facilitate the development of appropriate research methods, review progress of research and activities in SLOSEA's six initiative areas and assist with the integration of research and management decisions (SLOSEA, 2008). The Science Team also meets on an as-needed basis (SLOSEA, 2008).

SLOSEA partners are members of the community that take part in SLOSEA discussions and activities and/or are hired as consultants for SLOSEA's initiatives (SLOSEA, 2008). They meet with the Leadership Team, Advisory Committee, and Science Team as needed (SLOSEA, 2008).

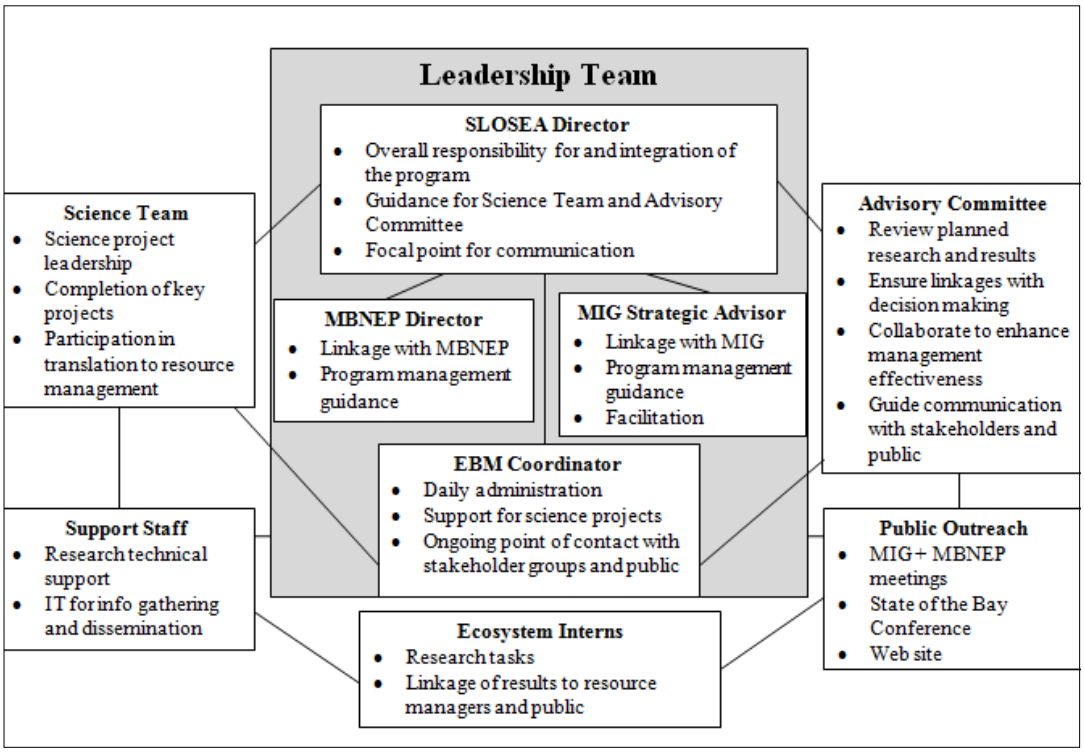

Figure 3: Diagram of SLOSEA organizational structure (Adapted from SLOSEA, 2007). [Note: This diagram is no longer current as it does not include SLOSEA's Marine Policy and Communications Manager).

Strategies and Tools

Diverse Stakeholder Engagement, Including the Public

To ensure an integrated management effort that involved cross-agency and inter-sectoral collaboration, SLOSEA built upon previous efforts of the MBNEP and MIG and engaged representatives from diverse ecosystem interests in planning and management activities. By ensuring key agencies participate on the Advisory Committee, SLOSEA has established a means of informing multiple relevant institutions of their research results, which enhances opportunities for integrating decisions and actions across agencies (Wendt et al., 2009). In addition, the involvement of different groups allows for knowledge from different sources to be incorporated into decision-making processes. Once this group was formed, a collective vision for the ecosystem was articulated based on common objectives and expectations for SLOSEA. This vision provides direction for the ongoing evolution of the organization and its activities (Wendt et al., 2009).

SLOSEA also interacts with the general public by holding public meetings and semi-annual public reviews of plans and research results. In addition, the MIG and MBNEP meetings are open to the public and updates regarding the EBM effort are discussed. For the collaborative

fisheries initiative, the public is invited to accompany local fishermen and scientists as they collect data on the health of local fish populations (SLOSEA, n.d. m).

Use of Conceptual Models

A conceptual model was developed of the coastal ocean, estuary and watershed that demonstrated connections between systems via species movements, freshwater inputs and tidal exchange (Figure 4). The model enabled managers and other stakeholders to identify key ecosystem connections, delineate boundaries, identify important questions and formulate hypotheses. Visual models also helped make the concept of EBM more understandable for some participants (Wendt et al., 2009).

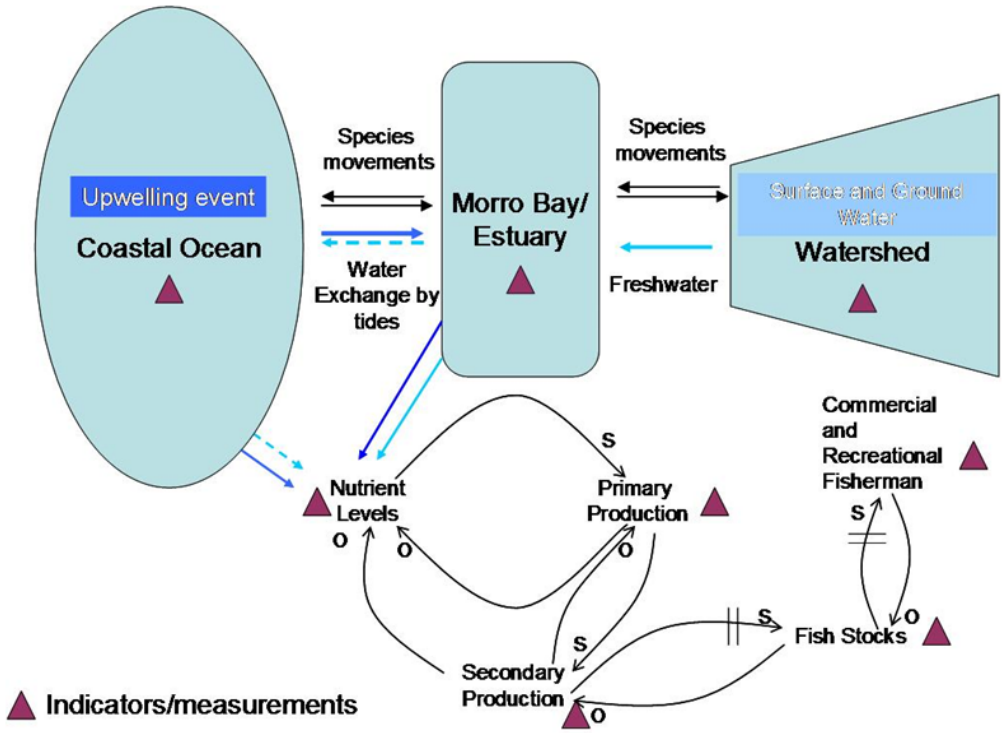

Figure 4: Conceptual systems diagram of the Morro Bay ecosystem. “s” indicates changes in the same direction. “o” denotes changes in the opposite direction. For example using water quality, the dark blue arrows denote water quality changes as a result of ocean water, and the light blue arrows denote water from the watershed. Following the arrows, one can track how an event such as an upwelling in the coastal ocean might affect eel grass production (primary production) in the bay/estuary (Wendt, 2006b).

Engaging Volunteer Monitors

Engaging volunteer monitors through the Morro Bay National Estuary Program’s Volunteer Monitoring Program has bolstered SLOSEA’s ability to monitor the ecosystem and collect various types of data. Over the last seven years, MBNEP Volunteer Monitoring Program (VMP)

volunteers have been collecting data related to water quality and invertebrate and vertebrate communities in the bay and associated freshwater sources (Morro Bay National Estuary Program [MBNEP], 2009). As of 2008, the MBNEP VMP had logged over 8,988 hours (MBNEP, 2009). These efforts will continue to provide managers and other SLOSEA participants with valuable information about the state of the ecosystem.

Pilot Projects and Adaptive Management

SLOSEA's efforts have been initiated within an adaptive management framework. For example, in an effort to determine how best to restore the native mussel-dominated fouling community in Morro Bay, scientists at Cal Poly conducted an experiment to remove invasive bryozoans. They found removal of the invasive species resulted in serial replacement by another invasive species, *Schizoporella unicornis*. Thus, it was determined that removal is an insufficient means of eradicating invasive species from the system. This management option has since been abandoned. By implementing this invasive species management strategy as an experiment, SLOSEA was able to recognize that the altered state of the ecosystem was resilient before investing a large amount of resources into the strategy (Wendt et al., 2009). Other activities are being approached in a similar manner.

Use of the Internet

The SLOSEA website was established as an interactive forum to provide interested parties opportunities to review research results, read project documents and meeting minutes, and contribute ecosystem observations and project input. Updates on project activities are posted to the website along with Advisory Committee presentations and relevant reports. SLOSEA has also used their website to collect survey data, and the organization maintains a listserv.

Surveying Users

The economic indicator initiative conducted surveys and discussions with participants in the local economy, which helped generate a clearer understanding of ecosystem-dependent activities and enabled economic indicators to be identified and monitored over time. Also, coastal user surveys were administered online and are currently being integrated into an environmental history database for the area.

Engaging in Collaborative Research with Fishermen

Within the context of SLOSEA's collaborative fisheries initiative, local knowledge and expertise of fishermen and skippers was combined with scientists' experimental design skills to develop a research protocol that is being used to evaluate local fish stocks and newly established marine protected areas. Both the fishermen and scientists are working to interpret the resulting data. This strategy has enhanced the sense of legitimacy among those involved and has increased trust between the scientists and fishermen.

Hiring a Policy and Communications Manager

To ensure the copious amounts of information SLOSEA has compiled and generated is shared with a wider audience and integrated into policy-making discussions, SLOSEA hired a Marine Policy and Communications Manager. This person is responsible for making connections between SLOSEA's research results and relevant resource management decision-making forums, and pursuing recommended policy changes.

Miradi Adaptive Management Software Tool

When developing its second strategic plan, SLOSEA used the Miradi Adaptive Management software tool that follows steps outlined by the Conservation Measures Partnership (CMP)[3] in its Open Standards for the Practice of Conservation (SLOSEA, 2008). SLOSEA chose this tool because the Standards have become widely-used among the conservation community. SLOSEA has an interest in taking on greater management responsibilities, and therefore, the organization felt it was appropriate to go through the rigorous planning process put forth in the Standards. This process enabled the organization to discuss and come to consensus on the forces influencing the ecosystem and those that SLOSEA should target with its activities (SLOSEA, 2008). From here, SLOSEA developed action and monitoring plans for each of its conservation targets, including a specific goal, strategies to achieve the goal, objectives of the strategies and activities to undertake for each strategy. Also, results chains were created that laid out SLOSEA's assumptions regarding how each strategy would enable them to reach their goals (SLOSEA, 2008).

Marine Protected Areas

To facilitate conservation of key resources, two marine protected areas were established in Morro Bay in 2007. While members of SLOSEA participated in the process that designated these areas, the MPAs in Morro Bay were established along with 27 other MPAs in the central coast region of California in accordance with the objectives of the Marine Life Protection Act (1999), not through a SLOSEA initiative. The Morro Bay State Marine Recreational Management Area (SMRMA) includes the area below mean high tide within Morro Bay east of the Morro Bay entrance breakwater and west of longitude 120° 50.34' W (Figure 5) (DFG, n.d. a). This area allows recreational hunting of waterfowl in line with hunting regulations; however, take of any or all living marine resources is prohibited with exceptions for recreational take of finfish and oyster aquaculture north of latitude 35° 19.70' N (Figure 5) (California Department of Fish and Game [DFG], n.d. a). A State Marine Reserve (SMR) is located in the bay below the mean high tide line east of longitude 120° 50.34' W. Here, take of all living marine resources is prohibited (DFG, n.d. a). Other temporal and spatial area closures have been established in nearshore waters to restore local fisheries such as the Rockfish Conservation Area in federal waters.

[3] See http://www.conservationmeasures.org (CMP web site) and http://miradi.org (Miradi web site)

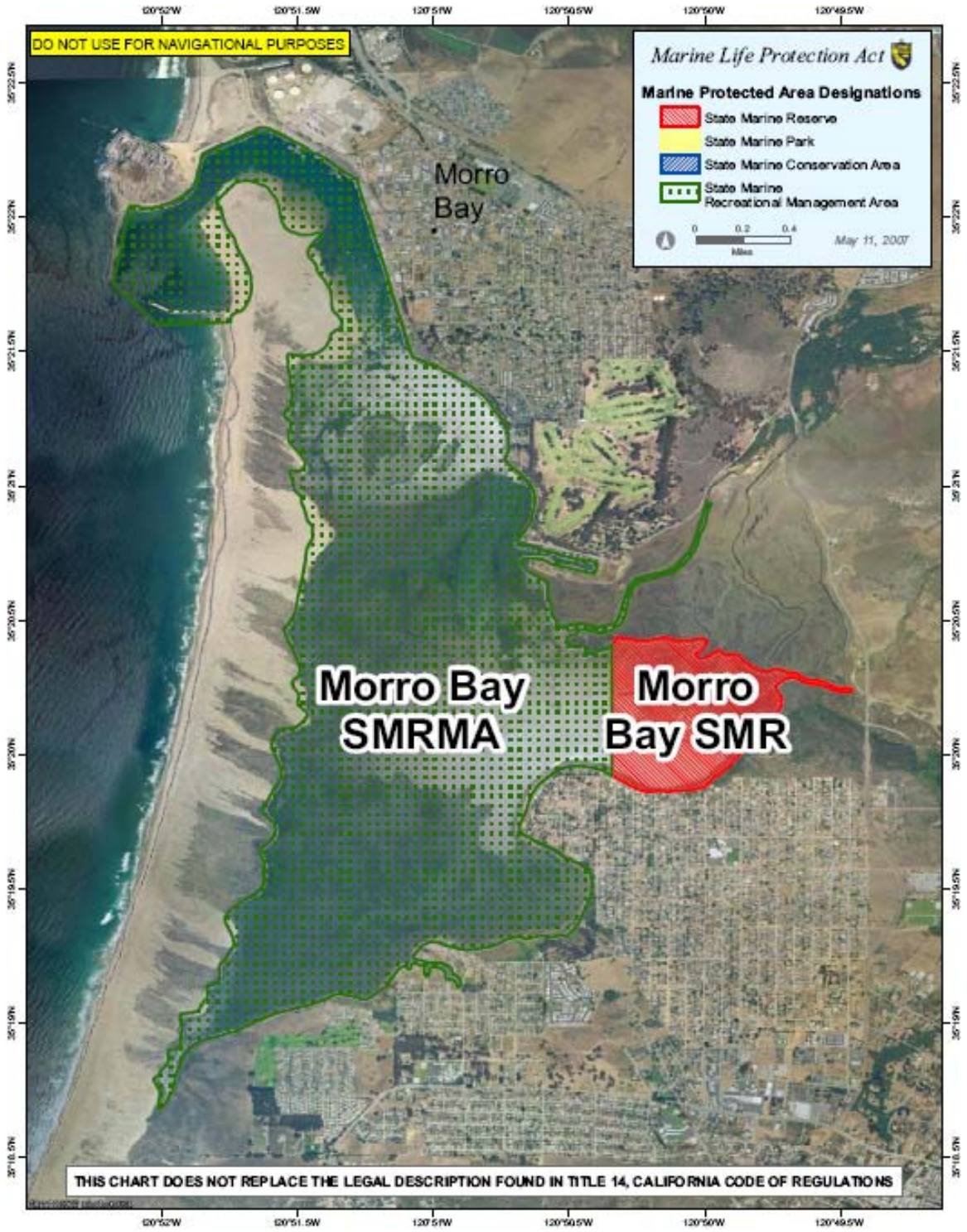

Figure 5: Map of Marine Protected Areas in Morro Bay (DFG, n.d. b).

Role of Science

Natural Science

Natural science has been the most abundant and dominant source of information in SLOSEA as evidenced by the disproportionate number of initiatives focused on ecological dynamics and employing natural scientific methodologies. As previously indicated, one of the main objectives of SLOSEA is to conduct science that will elucidate a better understanding of the ecosystem and inform management decisions. Consequently, natural scientific research and monitoring have been key components of each initiative and have contributed to SLOSEA's understanding of the distribution and condition of important resources and habitats, impacts of human access on rocky intertidal habitats, water quality dynamics and the status of offshore fish stocks.

Social Science

Social science played the largest role within the economic indicators initiative. As mentioned briefly above, surveys and informal interviews were conducted with key local actors to elicit input regarding economic activities affected by the condition of the estuary. These efforts helped generate a clearer understanding of ecosystem-dependent activities, and the results of these inquiries informed the selection of economic indicators.

Wendt et al. (2009) describes this process in a chapter in McLeod and Leslie's (2009) book, *Ecosystem-Based Management for the Oceans.* To develop a baseline of ecosystem-dependent human activities occurring in Morro Bay, a list of candidate indicators was assembled and shared with participating waterfront-business owners. These stakeholders were asked how each activity depended upon the ecological state of the bay. This approach collected necessary information and engaged the public in the process of scientific inquiry. A positive byproduct was that it also generated independent discussions among the participants about the linkages between the ecosystem and people, which allowed stakeholders to reach their own conclusions. In addition, the set of indicators was narrowed down by starting with a list of ecosystem services identified by the SLOSEA project team and then asking which economic activities may be impacted by changes to each of those services. By employing both of these strategies, the project team was able to narrow their list of potentially impacted economic activities down to those most sensitive to ecosystem conditions. Once the list was complete, data for the chosen indicators were collected from the relevant agencies, which included the California Department of Fish and Game, the Pacific Marine Fisheries Management Council, Duke Energy (the natural gas-fired power plant), the US Army Corps of Engineers, and the Morro Bay Harbor District.

Local Knowledge

As previously mentioned, within the context of SLOSEA's collaborative fisheries initiative, local knowledge possessed by fishermen and skippers was combined with the expertise of scientists to develop monitoring protocols "that could be used monitor MPAs and also serve to provide valuable information for fisheries management" (Starr et al., 2008). While scientists' skills were used to design a statistically sound protocol, fishermen's expertise was used to select fishing

locations and methods, and scientists and fishermen together interpreted the resulting data ("California Collaborative Fisheries Program," 2007).

Local knowledge of the ecosystem has also been collected via online surveys of coastal users, which is currently being integrated into the environmental history database mentioned above ("SLOSEA Advisory Committee Meeting: Meeting Notes," 2008). Furthermore, SLOSEA leaders believe the formation of the "integrated ecosystem group", the Advisory Committee, "is a modern representation of traditional ecological knowledge management systems" (Wendt et al., 2009). In recognition of the insights and information participants offer, SLOSEA has solicited input from its members during each stage of its activities.

Knowledge Gaps

Knowledge gaps are identified on an ongoing basis by members of the SLOSEA project team and are addressed through an adaptive process. As knowledge accumulates via the activities occurring within each of the initiatives, new questions are raised. When the project team meets, participants are able to discuss new questions and deliberate on strategies for addressing them. Possible solutions are then pursued as experiments. As results of these experiments are integrated, and the understanding of the state of the ecosystem and how its components interact, fluctuate and respond to management activities grows, activities and target issues are re-evaluated and re-prioritized as needed.

An example of SLOSEA's dynamic nature is provided within the context of the bioindicators initiative. While studying organisms in the bay to identify biological indicators, it was discovered resident gobies are developing liver tumors. This led to further investigation as to the source of the tumors, which happened to be the chemical nonlyphenol. Scientists working with SLOSEA probed further and found that nonlyphenol is in fact very abundant in the bay as well as elsewhere along the California coast. Now there is a growing interest within SLOSEA to engage the Regional Water Quality Control Board and other agencies at the federal level regarding nonlyphenol regulation.

Impacts

SLOSEA has been primarily focused on developing relationships among participants and generating information on relevant resources and habitats in the Morro Bay ecosystem for the first several years of its existence. To date, significant progress in each of its initiative areas, valuable ecosystem-based science has been conducted that has yielded a more comprehensive understanding of the system that has led to new agenda items on management and regulatory agencies' agendas, and SLOSEA has advanced the practice of ecosystem-based management.

Establishment and Maintenance of an Interagency Advisory Committee

Among SLOSEA's accomplishments has been the establishment and continued participation of SLOSEA's interagency Advisory Committee. The Advisory Committee has build upon past efforts of the MBNEP and MIG to provide forum for interagency collaboration and stakeholder

engagement that allows diverse perspectives to be shared, strategic relationships to be forged, new insights to be obtained and challenges to be identified for collective deliberation (SLOSEA, 2008). Through this group and the activities of the initiative areas, SLOSEA has successfully engaged different knowledge systems and expertise to be incorporating into research and planning processes, leading to feelings of reciprocal respect and mutual credibility (SLOSEA, 2008). As each Advisory Committee meeting begins with updates by the various agencies regarding recent and ongoing activities, this group has enabled a broad range of stakeholders to be aware of initiatives taking place throughout the ecosystem. The value of this group to its members has been expressed repeatedly during interviews with participants, and it has been evidenced by the ongoing involvement of its voluntary members.

Initiatives

For the habitat initiative, all navigable areas of the bay were mapped with multibeam bathymetry and sidescan sonar (Wendt, n.d.). Also, the distribution and topography of intertidal and salt marsh habitats were identified and mapped via hyperspectral and multispectral overflights of Morro Bay in collaboration with the Center for Integrative Coastal Observing, Research, and Education (CICORE) (Wendt, n.d.). These efforts have yielded depictions of bathymetry and topography contours for the Morro Bay harbor, mudflats, salt marsh and sand dunes (Wendt, n.d.). In addition, several ichthyofauna surveys have been completed in Morro Bay, which have enabled researchers to understand changes in fish diversity and abundance over a period of twelve months (Wendt, n.d.). In the future, this information will be combined with data from the real-time water quality monitoring network to produce a three-dimensional model of the ecosystem.

Within the context of the human access initiative, Multi-network Metadata System (MMS) data from 1980 was converted into GIS maps of plant and animal distributions along the San Luis Obispo County shoreline thereby contributing to a contiguous GIS map of the intertidal zone from Bodega Bay to the California-Mexico border. Shoreline surveys at state park access points assessed the extent and distribution of species sensitive to human access (Wendt, n.d.). Also, the two-year field experiment investigating human use impacts on rocky intertidal habitats was completed and provided valuable information to State Parks. The experiment elucidated the state of intertidal habitats before and after a simulated range of human impacts (i.e., low, medium and high access) (San Luis Obispo Science and Ecosystem Alliance [SLOSEA], 2009). The study found high levels of access caused shifts in the relative abundance of intertidal species (e.g., loss of large stands of sea palm) (Wendt, n.d.; SLOSEA, 2009). In addition to providing the study results to State Parks, SLOSEA presented their findings to the public and made recommendations for balancing conservation with public access through the production and dissemination of two Management Action Memos that are available online (SLOSEA, n.d. n). In coordination with these efforts, SLOSEA made specific recommendations to the California Department of Fish and Game regarding catch limits for species found in coastal habitats (SLOSEA, n.d. n).

Under the water quality initiative, key pollutant sources and impacts have been investigated. As mentioned previously, a network of continuous, real-time LOBO water quality monitors was established throughout the bay, watershed and at the mouth of Morro Bay in Estero Bay, and

since 2007 they have been continuously monitoring a variety of pollutants and abiotic parameters, including nitrates and dissolved oxygen, turbidity, and temperature (SLOSEA, n.d. b). Based on this data, an initial hydrodynamic model was developed that can be used to track and predict movements of land-based pollutants across the ecosystem (SLOSEA, n.d. b). The monitoring system is also being incorporated into a state-wide project implemented by the Regional Water Quality Control Board, the Surface Water Ambient Monitoring Program (SWAMP), which is assessing surface water conditions throughout the state ("SLOSEA Advisory Committee Meeting: Meeting Notes," 2009). Furthermore, key marine species such as shellfish and finfish are now being screened for potential pollution impacts (SLOSEA, n.d. b).

Indicator organisms for tracking nitrate pollution have been identified in Morro Bay under the bioindicators initiative (Wendt, n.d.). Also, a Mussel and Oyster Watch program was established (Wendt, n.d.). In addition, as previously discussed, the bioindicators initiative yielded an unexpected discovery, the presence of high levels of the industrial pollutant nonylphenol in the bay's sediment, water and resident organisms. While it has been banned in Europe, nonylphenol is still found in household products in the United States such as detergents and cosmetics. Scientists at Cal Poly linked this pollutant to abnormal tumors in resident goby fish as well as the development of female anatomy in male fish. SLOSEA is now engaging regulatory agencies to address the issue of nonylphenol pollution throughout the state and other parts of the country (SLOSEA, n.d. b).

Under the economic indicators initiative, a three-year study of ecosystem-dependent business activities in Morro Bay was completed. The results of this study have contributed to a growing understanding of linkages between economic activities and changes in ecological conditions and the data is being complied and incorporated into "an interactive website where decision-makers and the public can explore the linkages between the health of the ecosystem and the local waterfront economy" (SLOSEA, n.d. o). Progress in this area, however, has been limited by lack of baseline ecological data. Interactive, online activities were established that allowed stakeholders with economic interests in the bay to investigate the connections between economic enterprises and various ecosystem dynamics, which had been mentioned in public forums as being the primary agents of change in the state of local fisheries, but may not actually interact as conventional knowledge predicts (Wendt et al., 2009).Through these efforts, SLOSEA has contributed to the enthusiasm in the local business community and among local decision-makers to create a more diverse and stable marine economy (SLOSEA, n.d. o).

The collaborative fisheries initiative has been successful at fostering partnerships between fishermen, scientists and management agencies; collaboratively developing a fish stock monitoring protocol; creating a framework for regional fisheries management; and collecting data on local fish populations. The two main accomplishments of this initiative have been the collaborative development of a peer-reviewed monitoring protocol for evaluating nearby MPAs and monitoring the status of local fish stocks, and the drafting of an action plan with the California Department of Fish and Game, NOAA Fisheries Division and Ocean Protection Council (SLOSEA, n.d. m). The action plan explores opportunities for regional management using the novel CCFRP stock assessment protocol, and it discusses opportunities for developing portfolios of sustainable fishing opportunities (SLOSEA, n.d. m). Overviews and descriptions of the collaborative process used by the CCFRP have been published to inform others of the

approach and advise them on how to implement similar efforts. Also within this initiative, a comparative analysis of fishing data from 1978-1998 and 2003-2006 was conducted, and efforts were made to generate support for consideration of locally-derived data in stock assessment models used to set catch limits for nearshore fisheries (SLOSEA, n.d. m). Finally, SLOSEA has developed relationships with the Pacific Fisheries Management Council and National Marine Fisheries Service and has advocated in coordination with the MIG for the establishment of community fishing associations. SLOSEA recognizes these associations as valuable partners in conservation (SLOSEA, n.d. m).

Invasive Species Management

Advances have also been made towards identifying, detecting, and controlling marine invasive species. Scientists have determined the extent of invasive invertebrate species within the Morro Bay ecosystem and, as discussed earlier, research has concluded the bay experienced a change in community composition over the last thirty years from a system dominated by a native mussel to one dominated by an invasive bryozoan. The pilot management project for removing this invasive, already discussed, informed future management activities and understanding of the system's resilience. Lastly, the community and habitat characteristics that facilitate or inhibit the extent to which a community is susceptible to invasion have been determined, and this information is informing future efforts to limit the spread of invasive species.

Climate Change

In SLOSEA's recent efforts to address climate change and its potential to instigate more intense storm systems and coastal erosion, reduce wildlife habitat and further degrade water quality, the organization has made incremental progress in a few key areas. The network of water quality monitors established in the estuary and coastal waters is continuously providing data that has been made available to resource managers, decision-makers and the public via the SLOSEA website (www.slosea.org) (SLOSEA, n.d. p). This data is helping managers monitor changing conditions in the bay and will help inform predictions about impacts of climate change. Also, habitat and bathymetry data are being incorporated into maps and models of current ecosystem conditions (SLOSEA, n.d. p). Finally, the hydrodynamic model has been calibrated and is being used to simulate the effects of tides and currents within the estuary. This model is also being used to predict effects of climate change at a local level (SLOSEA, n.d. p).

West Coast EBM Network

In 2008, SLOSEA joined other west coast EBM initiatives in forming a network to strengthen their initiatives and enhance their effectiveness. There was an evident need to associate and align the EBM efforts supported by the Packard Foundation, Surfrider Foundation, Ocean Foundation, and the NOAA Coastal Services Center on the west coast (i.e., the San Juan Initiative in Washington, Port Orford Ocean Resource Team in Oregon, Humboldt Bay Initiative in northern California, Elkhorn Slough in central California, SLOSEA, and Ventura River Ecosystem Project in southern California) (Hansen, 2009). The goals of the network are twofold: to develop a learning system involving EBM topic teams, training opportunities, and a compilation

of best practices, and to establish a presence of EBM in coastal management policy discussions within state, regional and federal activities (Hansen, 2009). The member EBM efforts have already met three times as a network in 2008 and 2009 (Hansen, 2009).

Sharing Experience with EBM Implementation

SLOSEA has also been proactive about sharing its experience with ecosystem-based management, and the organization, its approach and research findings have been written about in newspaper articles, academic literature, and reports on ocean management. SLOSEA has had articles written about its activities in the local Tribune and New Times. It has also been highlighted in the "Profiles of Progress" section of the Joint Oceans Commission Initiative Report "One Coast, One Future" ("SLOSEA Program Updates," 2009). In addition, researchers working within the SLOSEA initiatives have been publishing papers about their research and subsequent findings, and SLOSEA's experiences with EBM have been summarized in a chapter of the book, *Ecosystem-Based Management for the Oceans* (McLeod & Leslie, 2009).

Challenges

SLOSEA's efforts have been challenged by several factors as indicated in project documents and interviews with participants, including institutional fragmentation, mismatched scales, measuring economic value, communicating to diverse audiences and unsustainable funding.

Institutional Fragmentation

In the beginning, institutional isolation and fragmentation of research and management efforts posed obstacles to data integration, comprehensive understanding of ecosystem dynamics and ecosystem-level coordination of activities. SLOSEA addressed these issues by forming its interagency Advisory Committee, first bringing together local academic scientists and two multi-stakeholder groups already leading research, conservation and sustainable use efforts in Morro Bay. Then, SLOSEA solicited representatives from key government institutions, community groups and other interests across the ecosystem to participate, thereby facilitating cross-agency communication, strategic collaborations and coordination of decision-makers' informational needs and research activities. However, in spite of these successes at the local level, fragmented authority over land and resources still poses a challenge to coordinated incorporation of research findings into management decisions across agencies. As an elected official affiliated with SLOSEA observed:

> The first challenge is trying to coordinate agencies that have sovereign authority over different pieces of the puzzle. […] All these agencies that are built for the very specific purposes in mind. They don't necessarily communicate with one another very well. I think they would […] if they had time to, but they are all under stress to get their job done.

For example, the human access initiative that provided information to State Parks will only go so far as to limit how many people can access new public lands, but DFG has jurisdiction over bag limits for collecting invertebrates and, therefore, also needs to make use of SLOSEA's data to ensure newly opened sensitive intertidal habitats are not degraded by overharvesting. As another stakeholder affiliated with SLOSEA stated:

> We can bring [different agencies] together, [but] there isn't […] currently […] a structured way for them to play. […] There isn't a mandate from their organizations. [Collaborating] is not one of the things that they have to do. […] It's something that they know is good to do, and they like doing with us, and that's where I think these efforts to figure out how to get better collaboration and commitment is going to be key.

An additional challenge is agencies' unwillingness to relinquish authority, so-called "turf-wars".

Mismatched Scales

Presently, mismatches between scales (i.e., the mismatch between the scale of ecosystem dynamics and governance, and between research findings and policy-making processes) make it difficult for SLOSEA to use its scientific findings to change management. As mentioned earlier, SLOSEA itself lacks authority to make management and policy changes, and while it has successfully collected local data indicating the presence of pollutants such as nonylphenol in the bay and has developed a statistically valid stock assessment protocol for fisheries, SLOSEA has not yet been able to efficiently and effectively influence regulatory agencies' decisions to regulate nonylphenol and use locally-derived stock assessment data when setting fishery catch limits, respectively. This is because despite participation of relevant regulatory agency representatives (e.g., from the Regional Water Quality Control Board and Pacific Fisheries Management Council) on SLOSEA's Advisory Committee, the changes that must be made to existing policy must occur at federal or regional levels. Therefore, federal or regional level data are needed to make a convincing argument for policy change, an extensive amount of time and energy must be committed to advocating for these changes, and/or changes must be made to the structure of institutions and policy-making processes such that authority to make regulatory changes is invested in ecosystem-scale entities. For example, when referring to use of locally-derived fishery stock assessment data, a resource manager affiliated with SLOSEA observed:

> It's […] a regionalized, or local, approach, [but] […] that's not the way the regulatory system is set up.

When discussing EBM more broadly, a scientist affiliated with SLOSEA acknowledged:

> The system limits the amount of EBM. We talked about jurisdictional limitations and governance limitations and those sorts of things. So there are inherent limitations that don't allow you to approach some ideal [of ecosystem-based management].

A recent development at SLOSEA that will help address this issue by mobilizing the resources needed to pursue venues for disseminating and integrating research findings into policy-making discussions has been the hiring of a Marine Policy and Communications Manager. This person is now responsible for making connections between Cal Poly's research results and relevant resource management decision-making forums, and pursuing desirable policy changes. This new development will also ensure the wide amount of information SLOSEA has compiled and generated can be shared with a wider audience, which has been difficult up until this point due to limited human resources (Scientist, personal communication, September 2009).

Measuring Economic Value and Impacts

Within the economic indicators initiative, problems arose regarding approaches for measuring economic impact (e.g., gross revenue and expenditures) and economic value data (e.g., consumer and producer surplus or willingness of user to pay to participate in an activity beyond the costs of participation). These challenges resulted from private firms' reluctance to reveal gross or net revenue data, high costs of conducting consumer and producer surplus studies, as well as the difficulty of applying these studies to repeated time series (Wendt et al., 2009). SLOSEA overcame this obstacle by focusing their attention on using measures of economic output as indicators such as measures of physical output (e.g., landings of fish and volume of sediments removed) and measures of human activity (e.g., recreational visit days and park attendance) (Wendt et al., 2009). From here, estimates of economic impact and value from supplementary surveys and literature helped situate each indicator such that the relative importance of changes in particular indicators could be weighted (Wendt et al., 2009).

Communicating to Non-Technical Audiences

Once the integrated Advisory Committee was assembled, it was challenging to convey, and elicit feedback on, abstruse ecological concepts and scientific methodologies to non-technical and non-science participants (Wendt et al., 2009). This issue was addressed through the use of more colloquial language, professional facilitation of advisory committee meetings, conceptual diagrams, and graphic representations of information (Wendt et al., 2009). Creating a conceptual model of the ecosystem was among the first outputs of the Advisory Committee and Science Team (Figure 4). As mentioned earlier, this model enabled managers and other stakeholders to indentify key ecosystem connections, delineate boundaries, and identify important questions. From here, stakeholders were able to develop approaches to test different hypotheses of interest (Wendt et al., 2009). Visual models also helped make the concept of EBM more understandable for some participants (Wendt et al., 2009).

Unsustainable Funding

Lastly, as with any initiative catalyzed by grant funding, obtaining a continuous source of financial resources poses a challenge to SLOSEA's sustainability. As the economic situation in the state of California plummeted in 2007 and 2008, and the Packard Foundation wound down its support for EBM programs in 2008, SLOSEA scaled back the frequency and location of its meetings. Establishing a more reliable stream of funding will be necessary to continue

SLOSEA's activities, including its interagency meetings and research efforts. As a stakeholder affiliated with SLOSEA observed:

> There's such complexity to the processes that you can't just […] do a snapshot and think you've got the whole picture and you […] understand these dynamics. […] So, finding ways to get ongoing support to sustain data collection on an ecosystem level to evaluate what's going on [is a challenge].

Facilitating Factors

As indicated in project documents and interviews with participants, SLOSEA's success has been facilitated by several key factors: the small size of the community, the local context in which SLOSEA was established, several pieces of EMB-promoting legislation at the state level, grant funding and the involvement of key personalities.

Small Scale

Relative to other estuaries in the state (e.g., the San Francisco Bay area) or other parts of the country (e.g., the Chesapeake Bay area), Morro Bay is a small ecosystem. While some of SLOSEA's activities take place beyond Morro Bay, its encompassing watershed and nearshore ocean, most of SLOSEA's meetings and activities take place in and around Morro Bay, which is a close-knit community surrounded by two other small cohesive communities, Los Osos and Cayucos. Many SLOSEA participants were familiar with one another to some degree prior to joining the Advisory Committee through other venues such as community forums and events. This familiarity among participants likely contributed to the comfortable and productive group dynamic that has emerged in the organization. A scientist affiliated with SLOSEA summarized the community's relationships as follows:

> We have really well-developed relationships with our community. That means the fishing communities, the environmental communities. These people are used to sitting down together around here. Even though they might yell at each other and not be as civil as they should, they've interacted for years now together, so I think that we're in a good position.

In addition, because of the small scale, community members are connected to their environment and share a sense of stewardship for it. A stakeholder affiliated with SLOSEA described the opportunity provided by the area's small scale and intimate connections between the people and environment as follows:

> I think the facilitating factors here are that […] it's a fairly workable scale here. […] There's this sort of sense that there is [a] connection to the environment, to the ecosystem, that you can observe. It's palpable. […] There's a […] sense that […] these things are really linked. […] There is this identification that people have with the environment, it makes sense to them, they can feel it and perceive it. [...] I think there's the interest and the willingness of people in the community,

> the local government and county government, and federal/state support and interest in this. […] There's a willingness of the stakeholders to work together. There's a willingness to listen to one another. There's a willingness to enable this ecosystem approach to flourish, because there are people who are willing to engage in learning with one another, understanding different perspectives.

History of Collective Action

The context in which SLOSEA was established also facilitated the program's success. In general, Californians support efforts taken to protect coastal and marine ecosystems, including the establishment of MPAs, making efforts to reduce water pollution and enacting related measures. Specifically in Morro Bay, there has been a legacy of activism beginning in the 1960's and a history of stakeholder engagement. Prior to the establishment of SLOSEA, the MBNEP and MIG were well established multi-stakeholder entities with research initiatives and conservation interests. Having these groups play central roles in SLOSEA from the beginning has facilitated SLOSEA's success. These groups have provided SLOSEA with forums for public engagement and interagency collaboration as well as human resources for collecting data and generating knowledge about ecosystem dynamics. Also, members of SLOSEA have been involved in collaborative initiatives such as the MLPA process. Furthermore, the area's abundant natural resources, which are valued by many, have contributed to the cooperative interactions among community members as an EBM partner explains:

> We have the richest biodiversity in any piece of earth in North America. […] We've got a marine environment. We've got the nearshore. We've got offshore. We've got coastal. We've got agricultural. We've got chaparral. […] It's easy to find common ground. Fishermen want good water quality. Conservationists want good water quality, and it seems to be that it's an easy place to find common ground […] because of our rich natural resources.

State Legislation

The interest of regulatory agencies to become involved in this initiative on a voluntary basis was likely facilitated by the state's proactive attitude towards holistic marine management. In the past decade, the state government in California has led the country in passing legal mandates to protect marine resources, and one of the first pieces of state legislation that encouraged holistic marine resource management was the 1998 Marine Life Management Act (MLMA). This act aimed to conserve marine ecosystems, sustain and restore fisheries, and ensure the long-term health of fishing communities (Sutton, 2005). At the time, it embodied some of the most advanced fisheries management concepts in the country and it demonstrated the shift in management foci from single species to ecosystems (The David and Lucile Packard Foundation [Packard], 2008). Also, the state legislature passed the Marine Life Protection Act (MLPA) in 1999. This piece of legislation entailed an unprecedented requirement to develop a statewide network of marine protected areas to preserve the natural richness and abundance of marine life as well as the complexity, organization and integrity of marine ecosystems off the California coast (Sutton, 2005; Packard, 2008).

In 2004, Governor Schwarzenegger signed the California Ocean Protection Act (COPA) (Packard, 2008). Rather than managing single species or resources, COPA again placed priority on the ecosystem and focused on protection, conservation and restoration at this level (Sutton, 2005). In coordination with COPA, Governor Schwarzenegger created the Ocean Protection Council (OPC) with the general mission to improve the protection and management of California's ocean and coastal resources. The OPC is a cabinet-level, multi-agency entity responsible for ensuring state policies are consistent with the principles of ecosystem-based management (Packard, 2008). It is intended to coordinate the state's agencies and laws responsible for protecting and enhancing ocean resources.

Since its establishment, the OPC has distinguished itself as a vehicle for agency reform, primarily through its development of a Science Advisory Council as well as some other measures (Packard, 2008). The OPC is also responsible for implementing the Governor's Ocean Action Pan that was released in October 2004 (Packard, 2008). This Action Plan recommends the development of EBM programs to help reach broad conservation, restoration and sustainability goals (Packard, 2008). COPA also established the Ocean Protection Trust Fund, which allocates funds for the Ocean Protection Council and was worth $26 million in 2005 (Sutton, 2005). In 2006, SLOSEA was a recipient of some of these funds since it fulfilled the COPA recommendation to develop EBM programs.

Also in 2004, after failure of two initial attempts to establish the statewide network of MPAs required by the 1999 MLPA, the Marine Life Protection Act Initiative was launched. This private-public partnership between the California Natural Resources Agency, California Department of Fish and Game, and the Resources Legacy Fund Foundation is facilitating the collaborative process to evaluate and further develop the state's network of MPAs. The first of four regions to take part in this MLPA process was the central coast region and members of SLOSEA and other community groups in and around Morro Bay participated. A scientist affiliated with SLOSEA summarized California's EBM-friendly context as follows:

> California's doing a lot of EBM activities. […] All the marine reserves that are being implemented – that's spatial management – one tool within EBM. […] We have some of our highest level governing bodies like the Ocean Protection Council whose mission is […] integrating jurisdictions and a focus on science for policy decisions and so on. […] They have a major influence in this state.

In 2006, the West Coast Governors' Agreement on Ocean Health was signed by the governors of California, Washington and Oregon. Through this agreement, the west coast states pledged their cooperation to one another in their efforts to fulfill federal policies and embark upon common activities such as ocean and coastal research (Packard, 2008). Two years later, in 2008, an Action Plan for implementation of the West Coast Governors' Agreement on Ocean Health was developed, providing a practical outline for fulfilling the agreement. The Action Plan reflects the Ocean Protection Council's strategic plan and the recommendations for marine ecosystem management described in the Pew Oceans Commission and the US Commission on Ocean Policy reports (Packard, 2008).

Grant Funding

As mentioned briefly above, grant funding has been fundamental to the establishment of SLOSEA's ecosystem-based management effort. To date, SLOSEA has received funding from the California Coastal Marine Initiative of the Resources Legacy Fund Foundation, Cal Poly State University, The David and Lucile Packard Foundation, the California Ocean Protection Council, California Coastal Conservancy, the Morro Bay National Estuary Program, and the Campbell Foundation. These grants have made the EBM effort in Morro Bay possible, providing the financial resources needed to hire staff and consultants, convene meetings, conduct research and coordinate activities within each of the initiative areas.

Respected Leadership

Lastly, the personalities of those involved in SLOSEA have facilitated fruitful interactions among participants. The participants of SLOSEA's Advisory Committee repeatedly expressed the importance of having particular personality types involved in the effort such as people that are perceived as approachable and to be participating out of genuine concern for, and interest in, the area. So far, participants have attributed many of their successful interactions to the people involved, and everyone seems to strongly approve of SLOSEA's Director. Such interpersonal dynamics likely enable group cohesion and collaboration. An ocean advocate affiliated with SLOSEA noted:

> Cal Poly has a good reputation in the area. […] I think people respect it and Cal Poly's motto is "learn by doing". They're very practical and rational. […] People know that and people can relate to it. I think that really helps. And I think [another] unique factor is that you have an incredibly good, very approachable scientist in charge of it. […] Something like this can't work unless there's key personalities and community groups that will support it. If the MIG hadn't existed, this wouldn't have started, so […] [this is] really [a] grassroots effort. […] It didn't come from a government agency at all. It came out of people's ideas and concern.

Lessons Learned

Several key lessons have been learned by SLOSEA's EBM program participants regarding the implementation of EBM (SLOSEA, 2007; Wendt et al., 2009).

Create a network of diverse stakeholders.

Creating a network of scientists, resource managers and other stakeholders that represent interests across the ecosystem will provide a beneficial forum for sharing information and facilitating mutual learning, identifying issues, forming collaborative partnerships, addressing tradeoffs between objectives and taking action.

"Start local, grow global."

SLOSEA's ability to scale up management to an ecosystem level was dependent upon a prior history of grassroots initiatives that cultivated relationships between groups of stakeholders, resource managers and scientists at a local level where it is easier for participants to connect to each other and their environment and observe interconnections. Afterwards, participants will be more open to expanding their perspectives to larger scale issues and solutions.

Use visuals as communication tools.

Developing visual models of ecosystem dynamics can help establish a framework for leading discussions, formulating hypotheses, testing questions and demonstrating concepts such as ecosystem-based management in a way that enables different participants to understand.

Conduct user-driven research.

Resource management issues should be used to guide scientific research. This is done by having resource managers and stakeholders identify critical questions of interest, and then having these questions pursued through appropriate scientific methodologies. This will help ensure resource managers who act as the primary implementers of management decisions share ownership of the scientific direction from the onset and will enhance the likelihood of the results being considered among management discussions. As an EBM partner explains:

> What we've found about ecosystem-based management is that you can engage a broad range of stakeholders and get them interested and develop their knowledge and focus and get actions that make a difference in the ecosystem. The flip side is that in order to sustain the interest of those groups you have to be talking about things that are relevant to them.

Create institutions that encourage mutual learning.

Learning should be a mutual. Shared experience that involves the integration of scientific investigations, policy development and public input will facilitate ownership over program outcomes and outputs. The development of collective learning opportunities enhances EBM activities by allowing diverse perspectives to be expressed and unique knowledge to be contributed.

Create flexible institutions.

It is essential to remain flexible and respond to new opportunities, challenges and potential learning experiences in a creative and adaptable manner.

Areas for Improvement

According to SLOSEA leadership, areas with potential to improve EBM implementation in California include the following (SLOSEA, 2008):

(1) Connections between local scale EBM projects and larger scale efforts should be enhanced.

(2) Policy (e.g., MOUs) or funding incentives should be pursued from agency staff by organizations trying to implement EBM to ensure long-term involvement.

(3) EBM could be enhanced by more localized decision-making and management such as regional fisheries management.

(4) More active efforts should be made to develop the concept of EBM for policy makers, scientists, resource managers and stakeholders.

(5) New tools need to be developed to assess tradeoffs and cumulative impacts.

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